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Three new species of the genus *Cheilea* from the Atlantic Ocean (Gastropoda: Hipponicidae)

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ABSTRACT

Individuals from populations previously thought to represent *Cheilea equestris* (Linnaeus, 1758) are studied, showing that they belong to diffferent species. Three new species are described and named herein: one from the eastern Atlantic, another from the western Atlantic and a third one with amphiatlantic distribution. A lectotype for the type species of the genus is designated.

INTRODUCTION

Since the latter half of the 20th Century, the genus *Cheilea* Modeer, 1793 underwent several changes both in taxonomic status and systematic position: Thiele (1929) and Wenz (1940) placed it in Amaltheidae (= Hipponicidae); Kuroda (1941) in Calyptraeidae; Ludbrook (1941) in the family Cheileidae Macpherson and Chaple, 1951, superfamily "Cheileacea." Iredale and McMichael (1962) and Kuroda et al. (1971) kept it in Cheileidae. Rehder (1980) placed it in Crepidulidae. Vaught (1989) and more recently Bouchet and Rocroi (2005) placed it in the family Hipponicidae Troschel, 1861.

Linnaeus (1758) described the species *Patella equestris* from the Indian Ocean. His types, deposited at the Linnean Society (Figures 1–3) seem to belong to two distinct species, but they do not bear detailed locality data. Moreover, they are difficult to study due the erosion of their protoconch.

Linnaeus mentioned "O. Indico" as the type locality for the species; despite that, several populations from different areas and oceans have been associated to the name *Cheilea equestris*. We list some of them herein:

Indo-Pacific: California to Chile (Abbott, 1974); Red Sea (Sharabati, 1984); Japan (Fukuda, 1990); India (Subba Rao, 2003); China, Japan, Philippines (Zhongyan, 2004); E. Pacific, Indo-Pacific (Rios, 2009); Easter Island (Rehder, 1980); Hawaii (Severns, 2011).

Atlantic: Florida, West Indies and Brazil (Abbott, 1974); Yucatan, Mexico (Vokes and Vokes, 1983); Caribbean Dutch islands (de Jong and Coomans, 1988); Florida, West Indies, Brazil: Amapá to Espírito Santo, Fernando de Noronha Archipelago, Davis Seamount (Læal, 1991); São Tomé and Principe (Fernandes and Rolán, 1993); Bahamas (Redfern, 2001); Brazil, West Atlantic, Canary, Madeira, Ascension (Rios, 2009); Cape Verde Archipelago (Rolán, 2005). Some records for Canary and Madeira (Cosel, 1982) have not been confirmed by later general works.

Pantoli and Riggieri (1988) mention the species for the Italian Pliocene and consider it to be a cosmopolitan species.

Espinosa and Ortea (2011) described a new genus (*Milicheilea*) with shells similar to that of a *Cheilea* but smaller and having a very large internal prominence. The protoconch is apparently similar and it should be studied before acceptance of a distinct genus, as the internal prominence may be induced by the environment (for example, if the animal lives in cavities resulting in a wide shell to keep the body closed and occluded, or in acid environments that can dissolve the external shell while the internal one is protected by the soft parts).

Study and comparison of specimens from some of these populations have shown that they represent different species, which are similar in general external appearance only. Some of these species are described as new in the present paper.

MATERIALS AND METHODS

Descriptions of protoconch morphology follow the methodology and nomenclature described by Verduin (1986). Sex of some individuals in this study was inferred based on attachment of smaller males to the shells of females (Redfern, 2001: 48, fig. 206A) Institutional and other abbreviations used are: AMNH, American Museum of Natural History, New York, USA; BMSM, The Bailey-Matthews Shell Museum, Sanibel, Florida, USA; IES, Instituto de Ecología y Sistemática, Havana, Cuba; LS, Linnean Society, London, UK; MHNS, Museo de Historia Natural, Santiago de Compostela, Spain; MNCN, Museo Nacional de Ciencias Naturales, Madrid, Spain; MNHN, Muséum national d'Histoire naturelle, Paris, France; MNRJ, Museu Nacional/Universidad Federal,

Rio de Janeiro, Brazil; NHMUK, Natural History Museum United Kingdom, London, UK; CCR, collection of Colin Redfern, Boca Raton, Florida, USA (recently incorporated to BMSM); CFG, collection of Raúl Fernández-Garcés, Cienfuegos, Cuba; CPR, collection of Peter Ryall, Maria Rain, Austria; CSG, collection of Sandro Gori, Livorno, Sicily, Italy; lv, live-collected; s, empty shell; j, juvenile.

SYSTEMATICS

Family Hipponicidae Troschel, 1861

Genus *Cheilea* Modeer, 1793

Cheilea Modeer, 1793: 110.
Mitrularia Schumacher, 1817: 56.
Litliedaplus Owen, 1843: 147.
Calyptra H. Adams and A. Adams, 1854: 364.

Type Species: *Patella equestris* Linnaeus, 1758, by subsequent designation (Modeer, 1793)
Cheilea equestris (Linnaeus, 1758)
(Figures 1–8)

Patella equestris Linnaeus, 1758: 780; "O. Indico."

Type Material: In LS (A-F 0020204). Lectotype here designated (Figures 1–3).

Original Description: *"P. testa integra orbiculata, labio fornicali perpendiculari".*

Description: Shell cap-shaped, usually very irregular, with rugose, axial sculpture. Internally with an erect and flat curved process that begins under apex. Protoconch (Figures 7–8) with 1.75 whorls, the first 0.75 whorl with slightly rough surface, followed by smooth surface. Protoconch about 600 µm in maximum diameter. Rest of surface smooth. Teleoconch begins with about 25–35, very fine spiral lines.

Dimensions: About 37 mm in maximum diameter.

Distribution: *Cheilea equestris* has been considered to be a cosmopolitan species. Further studies may well show that it comprises a complex of several similar-looking species.

Lectotype Designation: In the LS collection the type material from Linnaeus evidently includes two different species. We have selected as the **lectotype** (Figures 1–3)

Figures 1–12. *Cheilea* species. **1–6.** *Cheilea equestris* (Linnaeus, 1758). **1–3.** *Patella equestris* Linnaeus, 1758. **Lectotype** selected from the material in the LS (A-F 0020204), 37 mm in diameter (Indian Ocean). **4–6.** Bali, 37.8 mm (MHNS). **7–8.** *Cheilea* cf. *equestris*, Panglao, Philippines (MHNS). **9–12.** *Cheilea striata* Nowell-Usticke, 1959. **9–10.** Juvenile, 1.5 mm, Abaco, Bahamas (CCR). **11–12.** juvenile with protoconch, 12.5 mm, Cienfuegos, Cuba (MHNS).

the shell that most closely agrees with the description and shells usually associated with the nominal species.

Remarks: The type locality is Indian Ocean. The Linnean material is badly eroded, so that the protoconchs could not be examined. We have presented (Figures 4–6) a shell from Bali (Indonesia) with the same diameter of the lectotype and with part of the protoconch preserved. This is similar to the protoconch of a juvenile from Philippines (Figures 7–8).

Cheilea striata Nowell-Usticke, 1959
(Figures 9–12)

Cheilea equestris striata Nowell-Usticke, 1959: 47, pl. 2, fig. 19. [Type locality: Judith's Fancy, St. Croix, U.S. Virgin Islands, Atlantic Ocean].

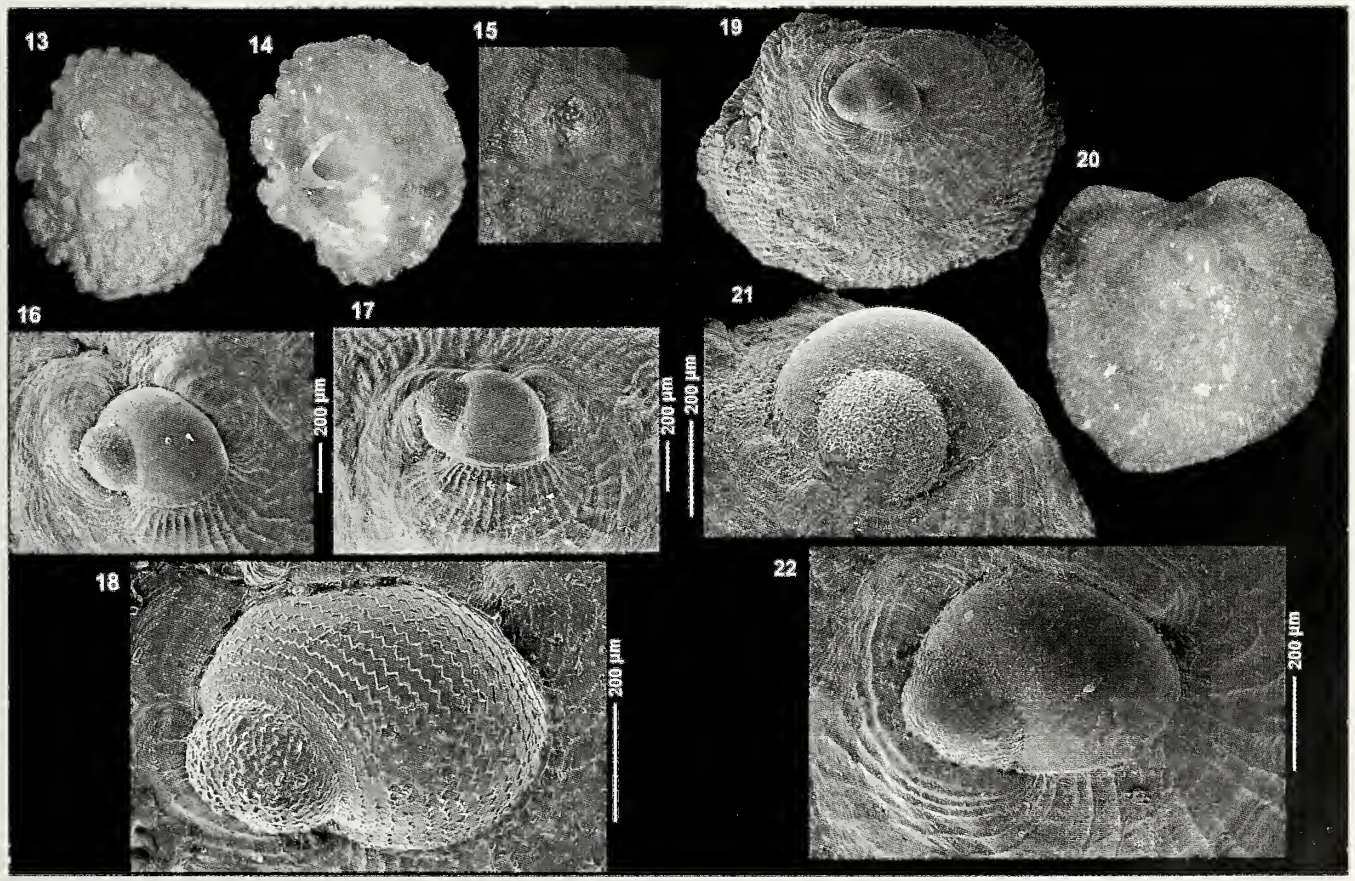
Type Material: Holotype: AMNH (198509). Paratype: AMNH 294373 (1 specimen). Not examined.

Other Material Examined: Cuba: 2 s, 2 j, Rancho Luna, Cienfuegos, 10-20 m (MHNS). Bahamas: 3 j, Abaco, 10 m (CCR).

Description: The protoconch (Figures 11–12) has only one whorl, the nucleus is wide, more than 250 µm and the entire protoconch is about 600–700 µm in diameter, with very fine spiral lines. The teleoconch is similar, with numerous radial striae crossed by isolated concentric lines.

Distribution: Known from the Virgin Islands (type locality), Bahamas, and Cuba.

Remarks: Nowell-Usticke (1959) described this species as a "form" having "strong raised radiating ribs roughly equal in size. On some shells these radiating ribs cross rather weak concentric lines". Nowell-Usticke (1959) referred to material ex-Usticke Collection (AMNH 198509) and Schwartz Collection (AMNH 294373). The repository of additional paratypes is unknown; its existence is indicated by Usticke (1959: 47) and the size range for the taxon is given as 20–40 mm length. Faber (1988: 90) considered this taxon to be a synonym of *C. equestris* (Linnaeus, 1758); we cannot agree with this view due to the consistent differences in protoconch morphology.



Figures 13–22. *Cheilea americana* new species. **13.** Holotype (female) (BMSM 17939) and paratype (male) on the dorsum, 19 and 7 mm, Abaco, Bahamas, ex-CCR. **14.** Ventral view. **15.** Male on the dorsum of the female shell. **16.** Protoconch of female (holotype). **17.** Protoconch of male (paratype). **18.** Protoconch of a juvenile, Abaco, Bahamas (CCR). **19.** Paratype, juvenile 2.4 mm, Rancho Luna, Cuba (MHNS). **20.** Paratype, juvenile, 3.5 mm, María la Gorda, W Cuba (MHNS). **21–22.** Protoconchs in two positions (Figure 21 from the shell of the Fig. 19).

Redfern (2001) illustrated the protoconch of Bahamian specimens externally and internally. These are very distinctive from the protoconch of *C. equestris*. Shells from Cuba are equal to those from Bahamas. Other species of this genus can be distinguished by their distinctive protoconchs.

***Cheilea americana* new species Rolán, Redfern, and Fernández-Garcés**
(Figures 13–18, 42–43)

Type Material: Holotype (female, sp) and a paratype (male, sp) in BMSM (17939) (Figures 13–14). Other paratypes: MNCN (15.05/60102, 1 j); MHNS (100593, 1 j, Figure 16) both from Maria la Gorda, 10–15 m, W Cuba); MNCN (15.05/60103, 2 s); MNHN (IM-2012-2112, 3 j), CCR (2 j), CFG (2 s, 2 j) and IES (1 s, 1 j), all from Rancho Luna, 10–20 m, Cuba).

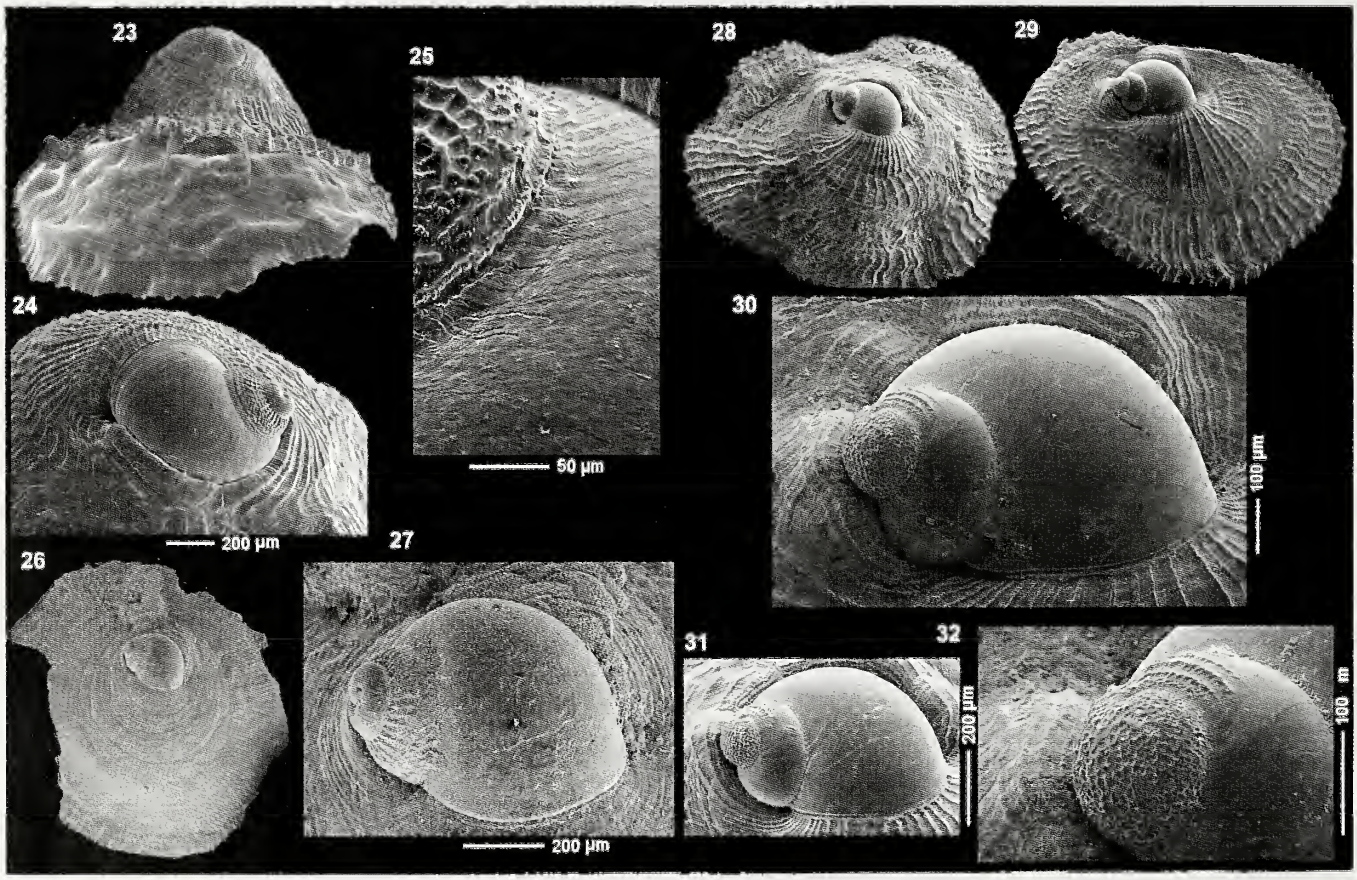
Type Locality: Reef off Great Guana Cay, 26°42′30″ N, 77°09′46″ W, Abaco, Bahamas, 4.5 m.

Etymology: The specific name refers to the continents off which the species was collected.

Other Material Examined: 1 sp, Chapéu Nordeste Island, Fernando de Noronha Archipelago, Brazil (MNRJ).

Description: Shell rather irregular, conical-depressed, as an inverted cup, whitish, with numerous radiating ribs. Protoconch (Figures 16–17) with 1.75 whorls, 530 µm in maximum diameter, nucleus about 100 µm. First 0.75 whorl very rough, subsequent whorl with zig-zag lines, often eroded (Figure 18). Initial part of the teleoconch with about 16–23 spiral cordlets; teleoconch expands quickly to partially envelop the protoconch. Rest of teleoconch very irregular, with prominences, undulating areas, and concentric scaly lines. Edge very irregular and inner surface with a prominence. Internally with an erect curved process, which begins under apex and is characteristic of genus.

Radula (Figures 42–43) with very wide rachidian teeth, each with very prominent central cusp and 8–9 smaller lateral cusps. Lateral teeth elongated, with about 5 cusps along cutting edge, most prominent one very large and wide; inner marginal teeth elongate, with wide and prominent cusp and 6–8 very small fine cusps on each side; outer marginal teeth similar to inner marginal teeth but narrower and with less cusps.



Figures 23–32. *Cheilea* species. **23–27.** *Cheilea atlantica* new species. **23.** Holotype, 7.2 mm, Montague Seamount, Brazil (MNRJ 25542). **24.** Protoconch. **25.** Detail of the microsculpture. **26.** Shell, 3.2 mm, Lagoa Azul, São Tomé I. (MHNS). **27.** Protoconch. **28–32.** *Cheilea africana* new species. **28–29.** Paratypes, 2.7, 2.57 mm, Regona, Cape Verde Archipelago (MHNS). **30–32.** Protoconch and detail.

Dimensions: Shell of female individual 19 mm in maximum diameter; male with 7 mm maximum diameter.

Distribution: Brazil, Bahamas, Cuba.

Remarks: *Cheilea equestris* has a more finely striated shell (Figures 1–3); the protoconch is larger (about 650 µm, Figure 7) and is less sculptured (Figures 7–8). For the differences with the other species see below.

***Cheilea atlantica* new species Rolán, Leal, and Fernández-Garcés**
(Figures 23–27)

Type Material: Holotype (Fig. 23) in MNRJ (25542). Paratypes: MNCN (15.05/60101, 1 s) from Santo Antonio de Palé, Annobon, Equatorial Guinea; MHNS (100594, 1 j, Figure 26) Lagoa Azul, São Tomé.

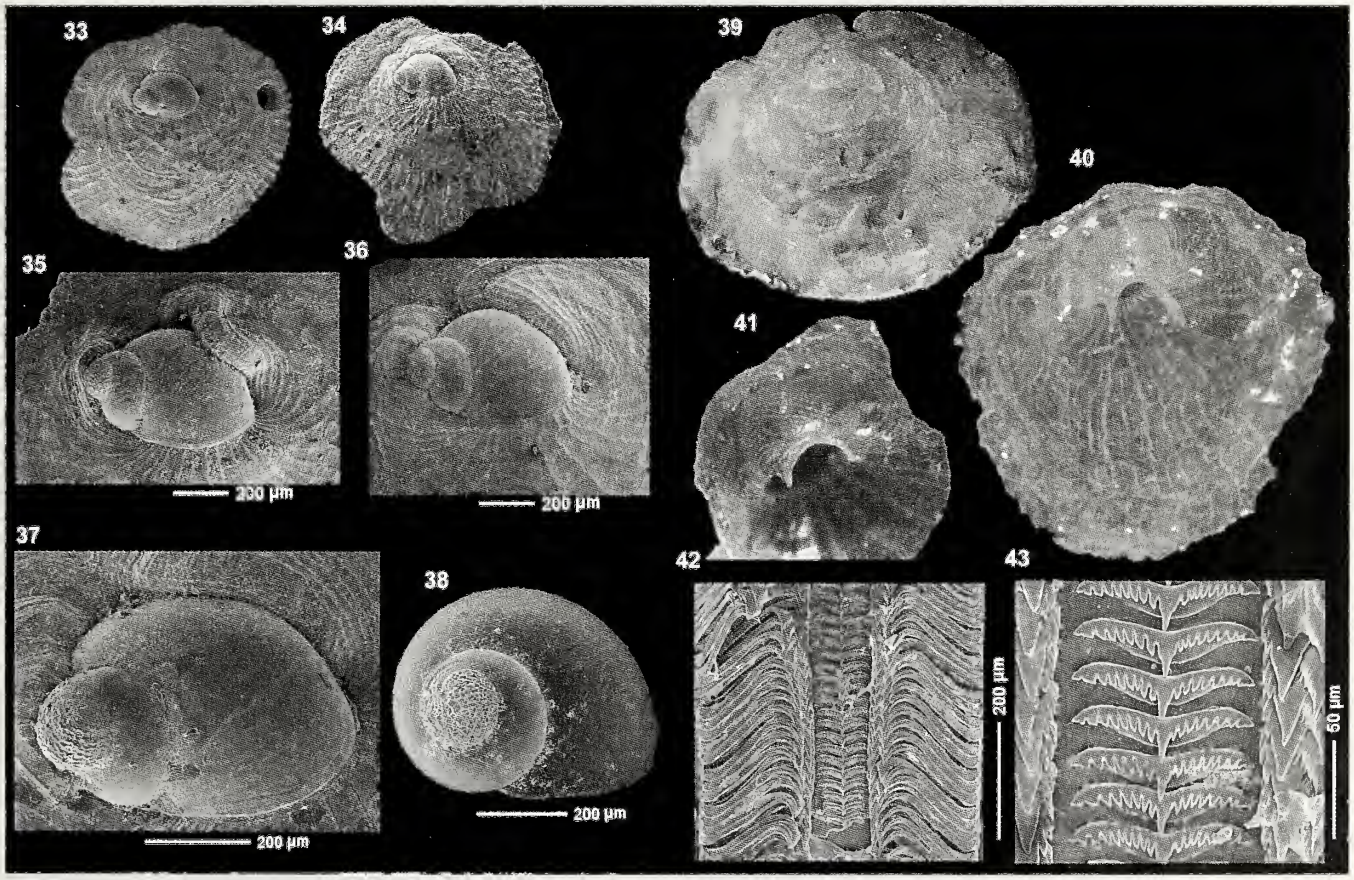
Other Material Examined: Cuba: 1 j, Rancho Luna, Cienfuegos, 10-20 m (MHNS).

Type Locality: Montague Seamount, Brazil.

Etymology: The specific name refers to the Ocean where the species was collected.

Description: Shell very irregular, approximately conical, solid, whitish with radial ribs. Protoconch (Figures 23, 27) with 2.75 whorls, maximum diameter 800 µm. Nucleus with about 130 µm. Nucleus and following 0.5 whorl lacking sculpture or only very lightly sculptured. Reticulated sculpture appears after nucleus and following 0.5 whorl. This lasts for 1.5 whorl. Last protoconch 0.5 whorl with very fine spiral striae and growth lines. Beginning of teleoconch with numerous (about 50–55) light spiral cordlets, which gradually separate: a group of these cordlets borders the protoconch on each side while others continue in front and centrally at the end last protoconch whorl. Internal shell surface with the erect and curved process, which begins under the apex and is characteristic of the genus.

Dimensions: Holotype 7.2 mm in diameter; a paratype (MNCN) reaches 11.7 mm in maximum diameter. The species may reach larger sizes, but one would need to see a complete shell with well-preserved protoconch ensure that it is actually the present species.



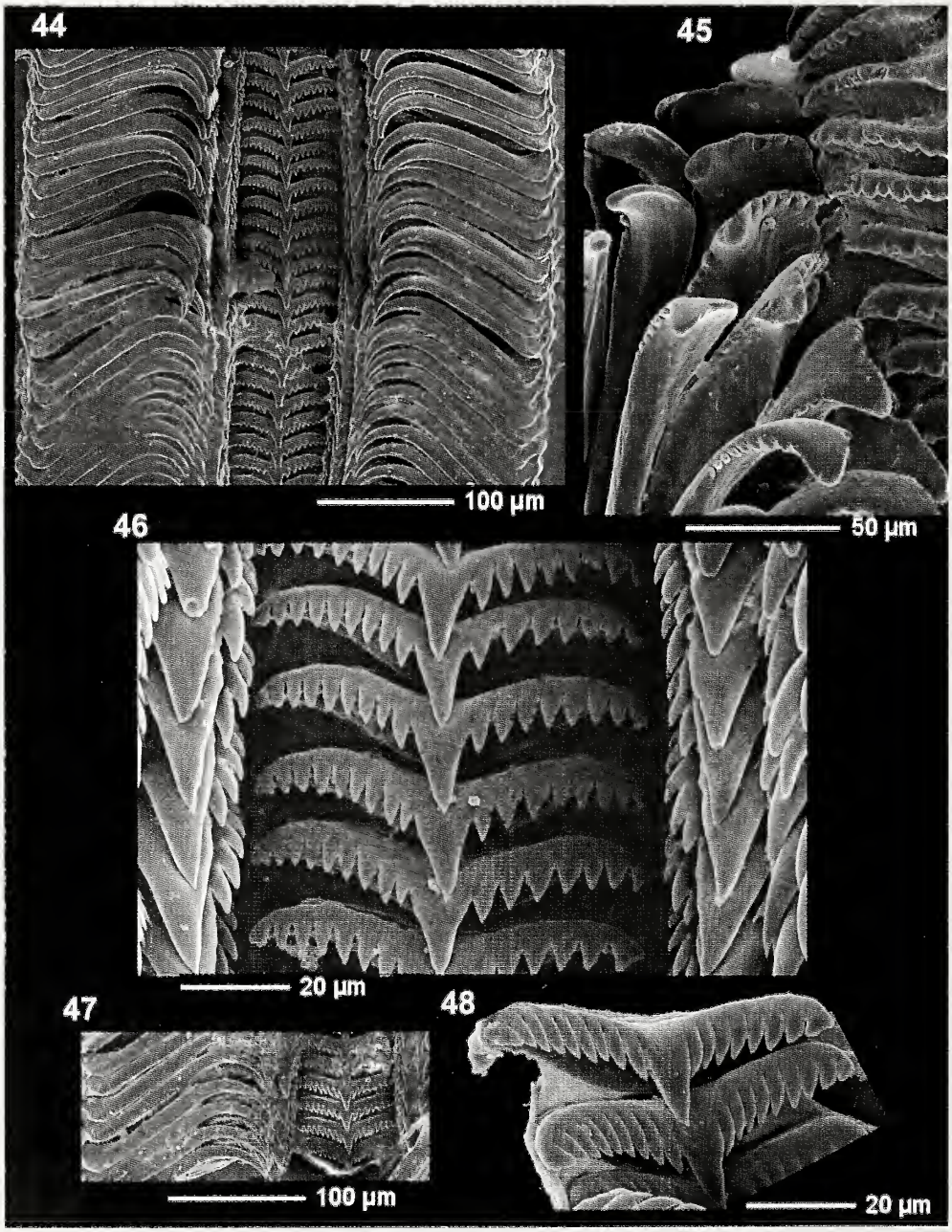
Figures 33–43. *Cheilea* species. **33–38.** *Cheilea africana* new species. **33.** Juvenile, 2.3 mm, São Tomé I. (MHNS). **34.** juvenile, 2.4 mm, Principe (MHNS). **35–38.** Protoconchs, Lagoa Azul and Esprainha, São Tomé Island. **39–41.** *Cheilea africana* new species. 39: holotype, 11 mm, Regona, Sal I., Cape Verde Archipelago (MNCN); 40: juvenile, internal face, 2.6, Miamia, Ghana; 41: juvenile, 1.3 mm, Lagoa Azul, São Tomé Island (MHNS). **42–43.** Radula of *Cheilea americana* new species, Chapéu Nordeste Island, Fernando de Noronha, Brazil.

Distribution: This is an Amphiatlantic species known from Brazil (holotype), Cuba (a juvenile), and from the islands of the Guinean Gulf (São Tomé and Annobon Is.) off the West African coast.

Remarks: *Cheilea atlantica* new species has a multispiral protoconch with more whorls than other known species and typical microsculpture not present on nucleus and on first ½ whorl, continuing with a reticulated section and ending on a distinctive section with very light sculpture. The teleoconch begins with very numerous light spiral lines. Since it the teleoconch is so variable, only the study of the protoconch allows for its conchological separation from other species. Apparently this species is living sympatrically with *Cheilea africana* in São Tomé and Annobon in West Africa and probably with *C. americana* new species in Brazil. The protoconchs of these two latter species are shorter, with only 2 and 1.75 whorls, respectively. In addition, the beginning of the protoconch of *Cheilea atlantica* new species is more sculptured.

***Cheilea africana* new species Rolán and Fernández-Garcés**
(Figures 28–41, 44–48)

Type Material: Holotype (15.05/60100, s, Figure 39) and 4 paratypes (15.05/60100, s) in MNCN, all from type locality. Paratypes in following collections: MNHN



Figures 44–48. *Cheilea africana* new species. Radula, Cape Verde Archipelago.

(IM-2012-2013, 6 s), Praia, Santhiago, Cape Verde; MHNS (100595, ex-12389, 5 s) (100595, ex-7031, 1 sp, 7 s) Mordeira, Sal Island, Cape Verde; CPR (1 s) Santa Maria, Sal Island, Cape Verde; CFG (1 s), Sal-Rei, Boavista Island, Cape Verde; MHNS (100595, 2 s, Figures 28–29), Lagoa Azul, São Tomé Island, São Tomé and Principe; CSG (6 j) Minerio, São Tomé Island, São Tomé and Principe, 41 m depth.

Type Locality: Regona, Sal Island, Cape Verde.

Other Material Examined: Senegal: 4 j, Dakar, 15 m (MHNS). Cape Verde Archipelago: 9 j, Regona, Sal I. (MHNS); 1 s, Palmeira, Sal I. 30 m (MHNS). Ghana: 6 j, Miamia, 25-35 m (MHNS). São Tomé and Principe, Principe Island: 4 j, Santo Antonio, 4-10 m (MHNS). São Tomé and Principe, São Tomé Island: 6 j, Minerio, 35–41 m (MHNS); 6 j, Lagoa Azul, 15 m (MHNS); 1 s, Esprainha, 8 m (MHNS). Annobon: 1 j, San Antonio de Palé, 5 m (NHNS).

Etymology: The species is named after the continent where the species was collected.

Description: Shell very irregular, approximately conical, solid, dirt-whitish. Protoconch about 650 maximum diameter, with about 2 whorls; embryonic shell well-defined including: nucleus measuring 140 µm and first half-whorl with rough and very irregular sculpture with rounded depressions, following 0.25 whorl presenting about 5–6 strong spiral lines with small threads between them. Separation between these two parts is well-defined. Last 1.25 whorls are smooth and have only growth lines. As can be seen internally in juveniles (Figures 40–41), its surface originally present numerous irregular spiral lines, which later disappear as a result of erosion. Beginning of teleoconch with numerous spiral lines (about 30–35) which gradually separate: a group at each side bordering the protoconch and another continuing centrally in front of last section of last protoconch whorl. Entire external surface irregularly striated, presenting numerous elevations, shell edge very irregular, conforming to substrate irregularities. Internally part with the erect curved process, which begins under the apex and is characteristic of the genus. Soft parts not observed. Radula (Figures 44–48) with wide central teeth with very prominent central cusp and 8–9 smaller lateral cusps; lateral elongate with about 6 cusps along cutting edge, one larger, plus 2–3 smaller outward; marginal teeth elongate, with a wide and prominent cusp and many, very small lateral cusps.

Dimensions: Largest shell measures 27.8 mm; the holotype is 11 mm.

Distribution: West Africa: Cape Verde, Senegal, Ghana, São Tomé and Principe, and Annobon.

Remarks: *Cheilea africana* new species may be distinguished from *C. striata* Nowell-Usticke, 1959 as this latter species has a protoconch with less than one whorl and a wider nucleus. *Cheilea americana* new species has a very similar protoconch, but with only 1.5 whorls, with more marked, zigzag spiral lines (when not eroded); furthermore, the protoconch is 100 µm smaller in diameter. The shell is very irregular externally but the radial striae are less visible. *Cheilea atlantica* new species has a protoconch with 2.75 whorls, the diameter is larger (more than 100–150 µm difference between *C. africana* and the larger *C. atlantica*), and the protoconch sculpture is different with a nucleus and 0.5 whorl almost smooth and subsequent 1.5 whorls strongly reticulated.

Conclusions: *Cheilea equestris* (Linnaeus, 1758) has been considered as a cosmopolitan species. The present study shows that more than one taxon had been lumped under that nominal species, most of them on the basis of shell characters only. This study may encourage similar efforts for additional populations living in areas geographically removed from the type locality of the nominal species. Such efforts will inevitably reveal additional unnamed species. It seems that, if nothing else, SEM studies of protoconchs and comparison with previously known species could be a fine method of separation.

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LITERATURE CITED

Abbott, R.T. 1974. American Seashells. Van Nostrand Reinhold Co. New York. 663 pp (second Edition).

Adams, H. and A. Adams. 1854. The Genera of Recent Mollusca; arranged according to their organization. The genera of Recent Mollusca; arranged according to their organization. John van Voorst, London, 2 vols. [1, 1–256, pls. 1–32 (1853); 1, 257–484, 2, 1–92, pls. 33–72 (1854); 2, 93–284, pls. 73–96(1855); 2, 285–412, pls. 97–112 (1856); 2, 413–540, pls. 113–128 (1857); 2, 541–660, pls. 129–138 (1858)].

Bouchet P. and J.-P. Rocroi. 2005. Classification and nomenclator of gastropod families. Malacologia 47: 1–397.

Cosel, R. von. 1982. Merine Mollusken der Kapverdischen Inseln. Übersicht mit zoogeographischen Anmerkungek. Courier aus der Forschungsinstitut Senckenberg 52: 35–76.

Espinosa J. and J. Ortea. 2011. Nuevas especies de moluscos gasteropodos (Mollusca: Gastropoda) con caracteres singulares, recolectadas en las cuevas submarinas de Cuba. Revista de la Academia Canaria de Ciencias 22: 189–198.

Faber, M.J. 1988. Studies on West Indian marine mollusks 13. The malaeological taxa of Gordon W. Nowell-Usticke. De Kreukel 24(4–5): 67–102.

Fernandes, F. and E. Rolán. 1993. Moluscos marinos de São Tomé y Principe: actualización bibliográfiea y nuevas aportaciones. Iberus 11: 31–47.

Fukuda, H. 1990. Marine Gastropoda (Mollusca) of the Ogasawara (Bonin) Islands. Part 1. Archaeogastropoda and Neotaenioglossa. Ogasawara Research 19: 1–86.

Iredale, T., and D.F. MeMichael. 1962. A reference list of the marine Mollusca of New South Wales. The Australian Museum, Sydney, Memoir 11: 1–109.

Jong, K.M. de and Coomans, H.E. 1988. Marine Gastropods from Curaçao, Aruba and Bonaire. Brill, Leiden, 261 pp.

Kuroda, T. 1941. A catalogue of molluscan shells from Taiwan (Formosa), with description of new species. Memoirs of the Faculty Sciences and Agriculture, Taihoku Imperial University 22: 65–216.

Kuroda, T., T. Habe, T., and K. Oyama. 1971. The Sea Shells of Sagami Bay. Tokyo, i–xix, 1–741 [Japanese], pls. 1–121, 1–489 [English], 1–51.

Leal, J. H. 1991. Marine Prosobranch Gastropods from Oceanic Islands off Brazil. W. Backhuys, Oegstgeest. 419 pp.

Linneus, C. 1758. Systema naturae per regna tria naturae secundum classes, ordines, genera, species, cum characteribus, differentiis, synonimis, locis. Editio decimal, reformata, tomus I. Laurenttii Salvii, Holmiae, 824 pp.

Ludbrook, N.H. 1941. Gastropoda from the Abattoirs Bore, Adelaide, South Australia, together with a list of some miscellaneous fossils from the bore. Transactions of the Royal Society of South Australia 65: 79–102.

Modeer, A. 1793. Inledning til kunskapen om Maskkräken i allmänhet; 4 Classen. Snäekor, Cochleata. Kongliga Vetenskaps Academiens Nya Handlingar 14 (4–6): 83–112.

Owen, [R.] 1843. On the anatomy of *Lithedaphus longirostris* Owen. Proceedings of the Zoological Soeiety of London 10 (118): 147–150.

Nowell-Usticke, G.W. 1959. A check list of the marine shells of St. Croix U. S. Virgin Islands with random annotations. Lane Press, Burlington, 90 pp.

Pantoli, D. and G. Ruggieri. 1988. La Cheilea del Pliocene Italiano. Bolletino Malacologico 24: 40–46.

Redfern, C. 2001. Bahamian Seashells. A thousand species from Abaco, Bahamas. Bahamianseashells, Boca Raton, 280 pp.

Rehder, H.A. 1980. The marine mollusks of Easter Island (Isla de Pascua) and Sala y Gomez. Smithsonian Contributions to Zoology 289: 1–167, pls. 1–14.

Rios, E. 2009. Compendium of Brazilian sea shells. Evangraf, Rio Grande, 668 pp.

Rolán, E. 2005. Malacological Fauna from the Cape Verde Archipelago. Conchbooks, Vigo, 455 pp.

Schumacher C.F. 1817. Essai d'un nouveau système des habitations des vers testacés. Schultz, Copenhagen, pp. [IV] + 288 + 22 pl.

Severns, M. 2011. Shells of the Hawaiian Islands. Conchbooks, Hackenheim, 564 pp.

Sharabati, D. 1984. Red Sea Shells. KPI Limited, London, 127 pp.

Subba Rao, N.V. 2003. Indian Seashells. Part. 1: Polyplacophora and Gastropoda. Reeords of the Zoological Survey of India, Occasional Paper 192: 1–416 pp.

Vaught, K.C. 1989. A classification of the living Mollusca. Ameriean Malacologists, Melbourne, 189 pp.

Verduin, A. 1986. *Alvania cimex* (l.) s.l. (Gastropoda, Prosobranchia), an aggregate species. Basteria 50: 25–32.

Vokes, H.E. and E.H. Vokes. 1983. Distribution of Shallow-Water Marine Mollusca, Yucatan Peninsula, Mexico. Mesoamerican Ecology Institute, Mon. 1, New Orleans, 183 pp.

Wenz, W. 1938–1944. Handbueh der Palaozoologie. 6. Gastropoda, I. Allgemeiner Teil und Prosobranchia. Gebrüder Borntraeger, Berlin, 1638 pp.

Zhongyan, Q.I. 2004. Seashells from China. China Ocean Press, Beijing, 418 pp, pls. 193.

Miocene vesicomyid species (Bivalvia) from Wakayama in southern Honshu, Japan

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ABSTRACT

A fossil association of potentially chemosymbiotic bivalves is reported from the lower Miocene Shikiya Formation in Kii Oshima Island, Wakayama Prefecture, Japan. The association is dominated by the elongate vesicomyid species *Adulomya uchimuraensis* (Kuroda, 1931); a second vesicomyid of lower abundance is here described as *Archivesica sakoi* new species. It represents the oldest species of the genus *Archivesica* and has a similar hinge structure as *"Calyptogena" laubieri* (Okutani and Métivier, 1986). Additional faunal elements include chemosymbiotic bivalves, namely the solemyid *Acharax* cf. *yokosukensis* Kanie and Kuramochi, 1995, and the lucinids *Lucinoma*? sp. and *Poumea*? sp., as well as the naticid gastropod *Euspira meisensis* (Makiyama, 1926). This association of fossil bivalves all with well-known chemosymbiotic living relatives suggests that these specimens lived at an ancient cold seep, and their mode of occurrence as mostly articulated shells parallel to the bedding plane indicates that were transported a short distance and then quickly buried.

Additional keywords: Miocene, *Archivesica*, *Adulomya*

INTRODUCTION

Vesicomyidae is one of the six extant bivalve families with a chemosymbiotic mode of life, with have a fossil history ranging back to the middle Eocene some 47 Million years ago (Kiel, 2010a). The vesicomyid fossil record of the Northwestern Pacific region is increasingly well studied and revealed the successive appearance, dominance, and disappearance of several genera. *Hubertschenckia* Takeda, 1953 was the only genus present during the late Eocene and Oligocene and it disappeared afterward; the elongate *Adulomya* Kuroda, 1931 dominated during the early and middle Miocene; and in the late Miocene both *Archivesica* Dall, 1908 and *Calyptogena* Dall, 1891 appeared and are the dominant vesicomyid genera until the present day (Amano and Jenkins, 2011; Amano and Kiel; 2007; 2010; 2011; 2012; Sasaki et al. 2005). Among those two genera, *Archivesica* was, and still is, much more species rich than *Calyptogena*.

When Amano and Jenkins (2011) investigated the fossil record of extant vesicomyid species in Japan, they questioned an identification by Katto and Masuda (1978) of an early Miocene species from the lower Miocene Shikiya Formation in southern Honshu as *Akebiconcha* cf. *kawamurai* Kuroda, which is an older name for the extant *Archivesica kawamurai*. Amano and Jenkins (2011) suspected that the Shikiya species may belong to *Archivesica*, but was not *A. kawamurai*. Moreover, Katto and Masuda (1978) identified an elongate bivalve from the same locality as *Cultellus izumoensis* Yokoyama, although the lot documentation was poor. Based on observations on the original material of Katto and Masuda (1978) and new material collected at their locality, both species are here identified as members of the Vesicomyidae: the ovate specimens previously identified as *Akebiconcha* cf. *kawamurai* is named as a new species of the genus *Archivesica*, and the specimens assigned to *Cultellus izumoensis* are identified as *Adulomya uchimuraensis* Kuroda, 1931. Here we describe these species and discuss their evolutionary significance. We also describe the locality in more detail, including its paleoecology and the mode of occurrence of these fossils and additional taxa.

MATERIALS AND METHODS

The specimens were recovered from a large block (ca. 7 × 4 × 4 m) and several small blocks in its vicinity along the boulder beach near a cliff about 400 m north of Oshima fishing port in Kii Oshima Island, Wakayama Prefecture, Japan (Figure 1; Katto and Masuda, 1978, Loc. no. 10). These blocks are derived from the cliff and consist of sandy siltstone of the uppermost lower to lowermost middle Miocene Shikiya Formation of the Kumano Group (Hisatomi, 1981). All shell material is dissolved and rubber casts were made from the internal and external molds to document the internal and external morphology of the species, including the hinge structure. However, many small pyrite grains and the rough surface of weathered shells prevent us from making rubber casts without bubbles. All specimens reported here are deposited at the Wakayama Prefectural Museum of Natural History (WMNH).

MODE OF OCCURRENCE

The bivalves occur in shell beds consisting of mostly articulated specimens lying parallel to the bedding plane, although valves that are opened to various degrees were also found (Figures 2–5). The matrix of these shell beds does not differ from the surrounding sandy siltstone. This mode of occurrence indicates that shells are not preserved in life position but may instead have been transported for a short distance and then quickly buried. In addition to the two vesicomyid species described here, two specimens of the giant solemyid *Acharax* cf. *yokosukensis* Kanie and Kuramochi, 1995 (reaching about 30 cm in length), one specimen each of the lucinid bivalves *Lucinoma*? sp. and *Poumea*? sp., and of the naticid gastropod *Euspira meisensis* (Makiyama, 1926) were found (Figures 6–10).

SYSTEMATICS

Family Vesicomyidae Dall and Simpson, 1901
Subfamily Pliocardiinae Woodring, 1925

Genus *Archivesica* Dall, 1908

Type Species: *Callocardia gigas* Dall, 1896, from the Gulf of California.

Archivesica sakoi new species
(Figures 11–17)

Akebiconcha cf. *kawamurai* Kuroda. Katto and Masuda, 1978: pl. 3, fig. 7.

Diagnosis: Medium-sized *Archivesica* with elongate ovate shell, no lunular incision, shallow and wide pallial sinus, and very shallow subumbonal pit; subumbonal cardinal tooth consisting of very small anterior (3a) and rather thick posterior (3b) teeth and thick cardinal tooth

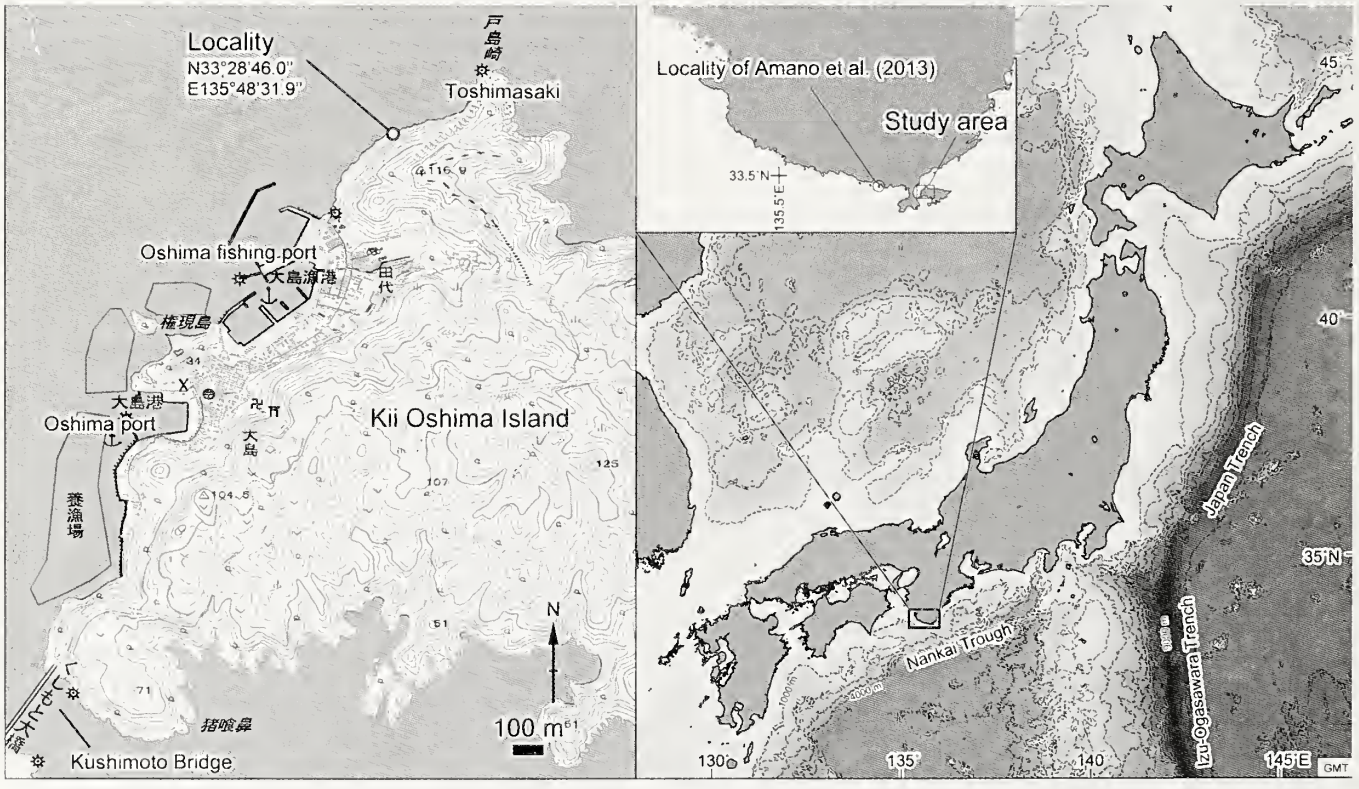


Figure 1. Locality of the vesicomyid fossils (left-side base map is from the "Kushimoto", scale 1:25,000 topographic map published by the Geospatial Information Authority of Japan).

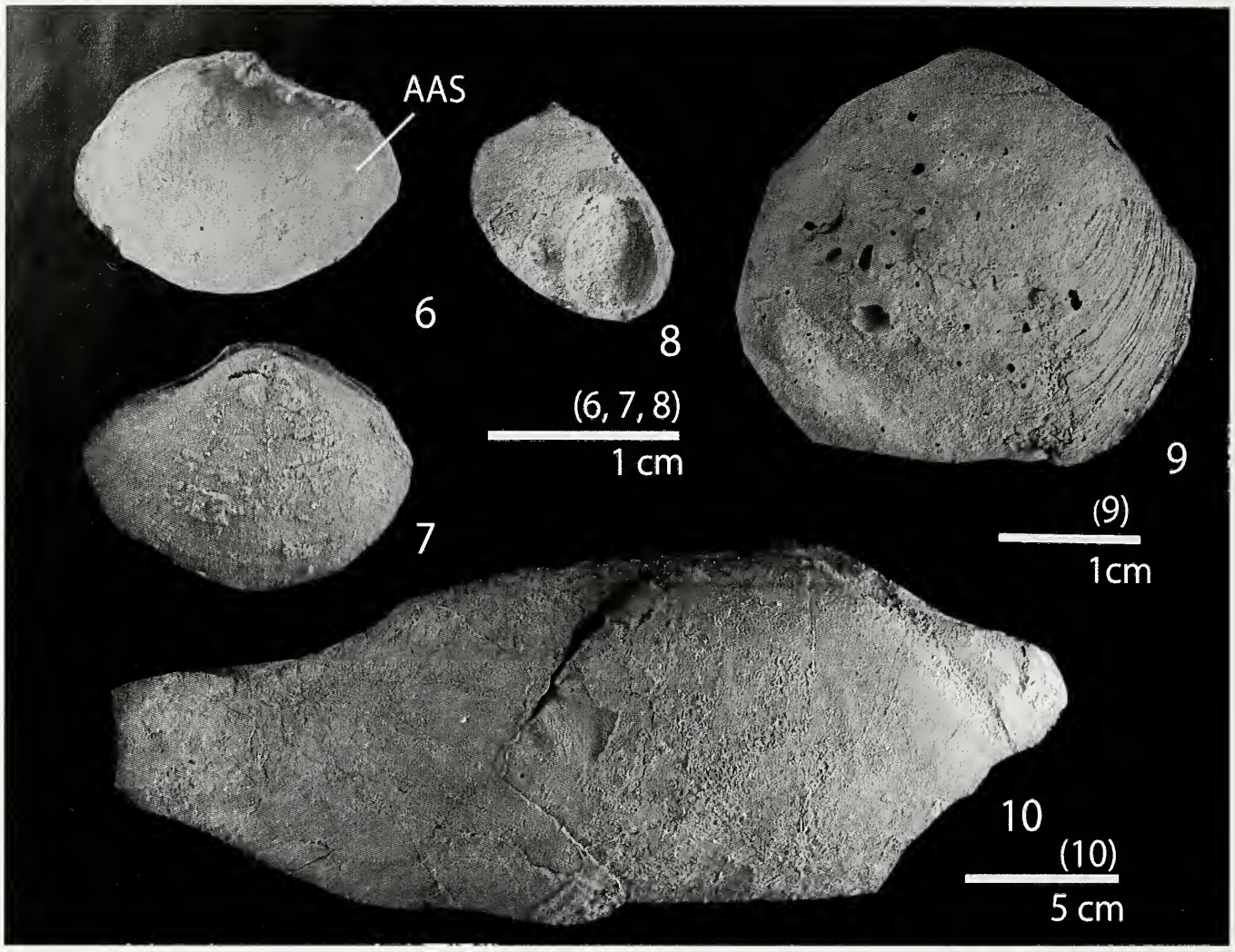
Figures 2–5. Field images of the outcrop. **2–4.** Large block yielding vesicomyid fossils, white arrow indicates a gregarious occurrence; enlargement of the southern side of the block (**3**), and close up of the gregarious occurrence (**4**). **5.** Cluster of *Adulomya uchimuraensis* Kuroda in a small block in the immediate vicinity of the large block.

(1) in right valve; subumbonal cardinal tooth consisting of thin anterior ramus (2a) and very thick triangular posterior tooth (2b) and posterior cardinal tooth (4b) very thin in left valve.

Description: Shell medium-sized for genus (up to 80.4 mm in length), moderately inflated, elongate-ovate (height/length = 0.48–0.56), equivalve and inequilateral. Antero-dorsal margin concave and continuing to rounded anterior margin; postero-dorsal margin nearly straight, posterior margin subtruncated; ventral margin broadly arcuate. Beak prominent, prosogyrate and located at anterior one-fifth to one-third of shell length (U%=22–34). Lunule absent. Surface ornamented with irregular commarginal lines. Right valve hinge wide for size, with three cardinal teeth and very shallow subumbonal pit. Anterior tooth (3a) in right valve very short and thin, connected with posterior tooth (3b). Posterior tooth (3b) rather thick, oblique posteriorly; middle cardinal tooth (1) moderately thick, oblique anteriorly. Left valve hinge wide, with three cardinal teeth. In left valve, anterior tooth (2a) thin, connected with middle tooth (2b); middle tooth (2b) triangular and very thick; posterior cardinal tooth (4b) very thin. Anterior adductor scar semicircular and deeply excavated; anterior pedal adductor scar narrow, quadrate and deeply excavated, distinct from adductor muscle scar; posterior adductor scar indistinct, ovate, situated directly above a weak ridge running from umbo to postero-ventral corner; pallial sinus shallow and wide.

Type Material: Holotype: Right valve, length, 63.2 mm, height, 31.3 mm, WMNH-Ge-5. Paratypes: Left valve, length, 48.7 mm+, height, 26.0 mm, WMNH-Ge-6; left valve, length, 59.5 mm, height, 30.5 mm+, WMNH-Ge-7; left valve, length, 80.4 mm, height, 39.2 mm, WMNH-Ge-8.

Type Locality: The coastal near cliff about 400 m north to Oshima fishing port in Kii Oshima Island, Kushimoto-cho, Wakayama Prefecture, Japan.

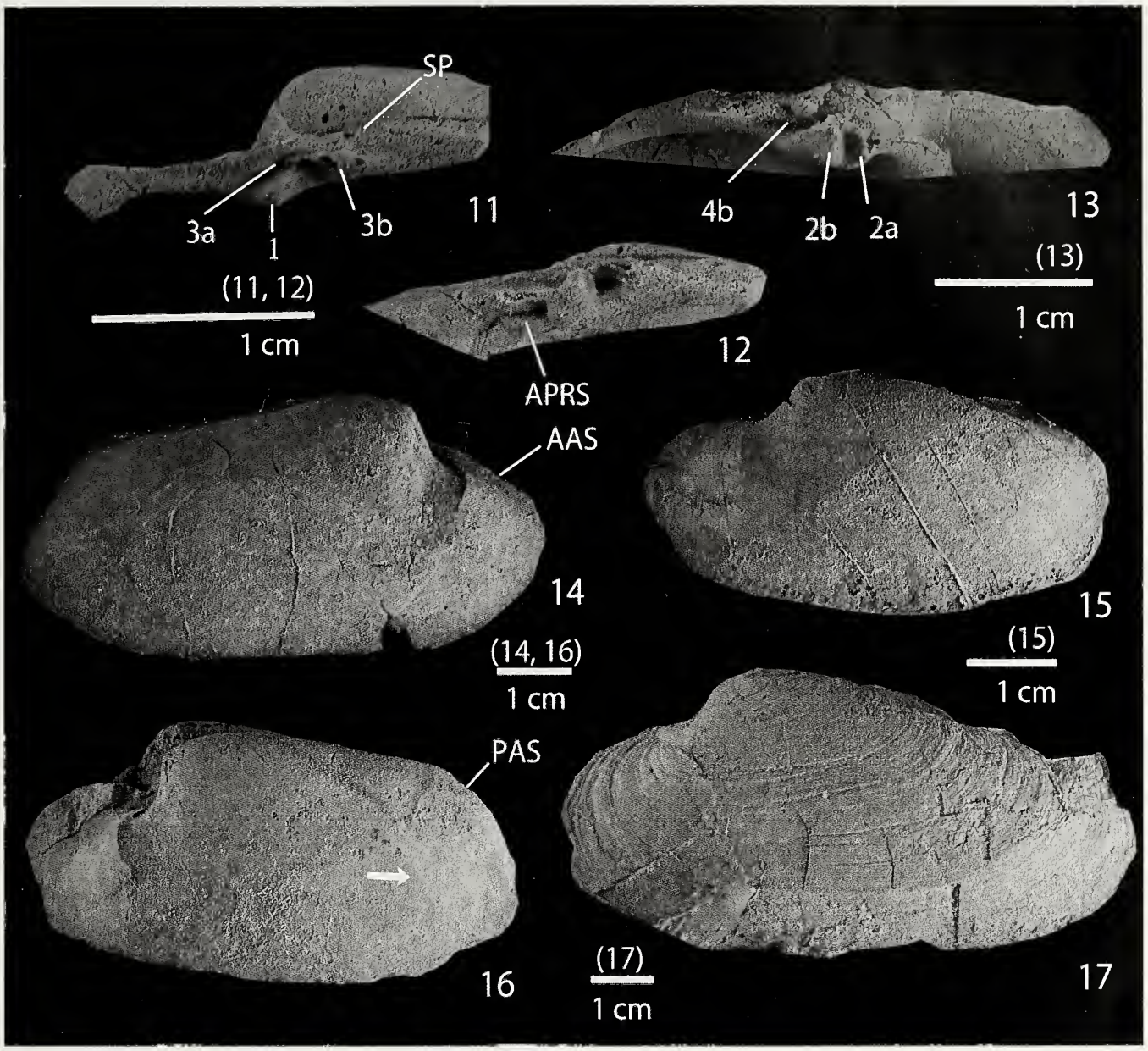


Figures 6–10. Mollusks associated with the vesicomyid bivalves described here. **6, 7.** The lucinid bivalve *Poumea*? sp. (WMNH-Ge-1120210284); **6**, rubber cast of the inner surface of a left valve showing elongate anterior adductor scar (AAS); **7**, internal mold. **8.** The naticid gastropod *Euspira meisensis* (Makiyama) (WMNH-Ge-1120210285), rubber cast. **9.** The lucinid bivalve *Lucinoma*? sp. (WMNH-Ge-1120210287), rubber cast of the external surface of a right valve. **10.** The solemyid bivalve *Acharax* cf. *yokosukensis* Kanie and Kuramochi (WMNH-Ge-1120210291), internal mold of a left valve.

Material Examined: Twelve specimens from the type locality.

Remarks: *Archivesica sakoi* new species was previously reported as *Akebiconcha* cf. *kawamurai* Kuroda, 1943 by Katto and Masuda (1978), but their illustration did not show the hinge structure. The outline of *Archivesica kawamurai* is indeed somewhat similar to that of *A. sakoi* except for being higher and larger. However, the subumbonal cardinal tooth of right valve enables us to easily separate both species. The right valve of the present new species has a small anterior tooth (3a) and posteriorly oblique posterior tooth (3b), while that of *A. kawamurai* has a larger anterior tooth and a posterior tooth that is slightly inclined anteriorly (Kuroda, 1943; Sasaki et al., 2005).

Comparisons: The right valve hinge of *Archivesica sakoi* is most similar to that of the Recent "*Calyptogena*" *laubieri* Okutani and Métivier, 1986 in having a small 3a tooth and a shallow subumbonal pit (Figure 18). A recent molecular phylogenetic analysis (Audzijonyte et al., 2012) indicates that this species is phylogenetically close to the type species of *Archivesica*, *A. gigas* (Dall, 1895). However, "*C.*" *laubieri* can be separated from the present new species by having a distinct blunt ridge running from beak to posterior end, a tapering posterior end, a very narrow hinge plate, a less stout middle tooth of left valve, and many distinct irregular growth lines on the outer surface (Figures 19, 22). The extant *Archivesica ochotica* Scarlato, 1981 also resembles this new species in a having broadly rounded ventral margin, a shallow pallial sinus, a rather small 3a tooth, a shallow subumbonal pit in the right valve, and a stout 2b tooth in the left valve (Figures 20, 21, 23). However, *A. ochotica* has a larger (105.0 mm long) and higher shell (H/L = 0.58), an overhanging posterior tooth above anterior and middle cardinal teeth of left valve, and



Figures 11–17. *Archivesica sakoi* new species. **11, 12, 15.** Paratype (WMNH-Ge- 1120210286); **11**, a rubber cast showing details of the hinge of a right valve; SP=subumbonal pit; **12**, ventral view showing the anterior pedal retractor scar (APRS); **15**, internal mold of left valve. **13, 16.** Paratype (WMNH-Ge-1120210288); **13**, rubber cast showing details of the hinge area of a left valve; **16**, view on the left valve of an internal mold, white arrow indicates the very shallow pallial sinus; PAS=posterior adductor scar. **14.** Holotype (WMNH-Ge-1120210283); view on the right valve of an internal mold; AAS=anterior adductor scar. **17.** Paratype (WMNH-Ge-1120210289), rubber cast showing the outer surface of a left valve.

a more roundly curved postero-dorsal margin than *Archivesica sakoi* new species.

Distribution: Lower Miocene Shikiya Formation at the type locality.

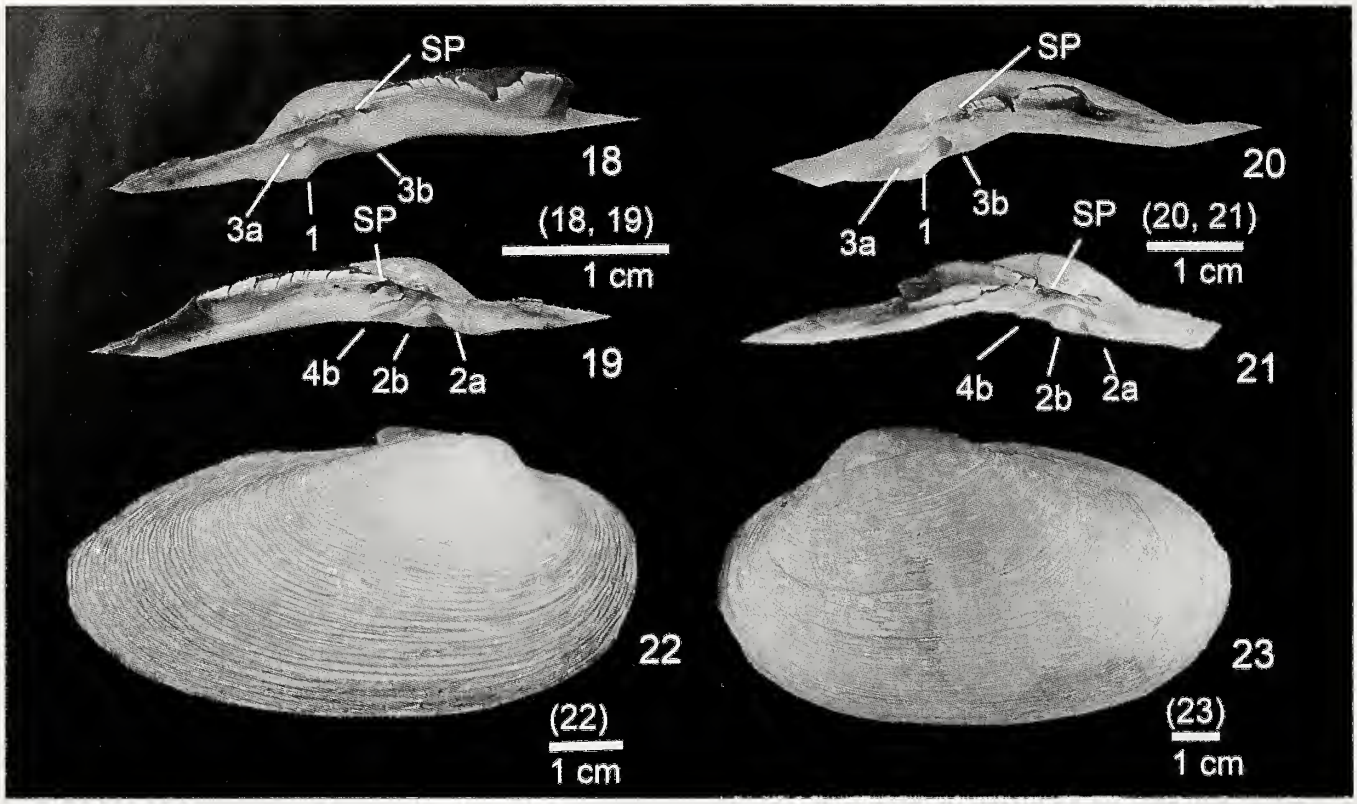
Etymology: Named after Mr. Yukio Sako who collected the type specimens and kindly offered them to the authors for study.

Genus *Adulomya* Kuroda, 1931

Type Species: *Adulomya uchimuraensis* Kuroda, 1931, from the middle Miocene Bessho Formation, central Honshu, Japan.

***Adulomya uchimuraensis* Kuroda, 1931**
(Figures 24–29)

Adulomya uchimuraensis Kuroda, 1931: 27–28, pl. 13, figs. 111–114; Tanaka, 1959: 117–118, pl. 1, fig. 1–10; Tanaka, 1960: 24–26, pl. 32, figs. 1–7; Amano and Kiel, 2011: 77–80, fig. 2.



Figures 18, 19, 22. *"Calyptogena" laubieri* Okutani and Métivier, 1986, Holotype (NSMT Mo 64158); **18**, hinge dentition of a right valve; SP=subumbonal pit; **19**, hinge dentition of a left valve; **22**, right side view of the holotype. **Figures 20, 21, 23.** *Archivesica ochotica* Scarlato, 1981, Holotype (ZIN AN SSSR no. 9912); **20**, hinge dentition of a right valve; **21**, hinge dentition of a left valve; **23**, left side view of the holotype.

Calyptogena (*Adulomya*) *uchimuraensis* Kuroda.—Kanno and Tanaka in Kanno et al., 1998: 20–22, figs. 7–8.
Calyptogena (*Adulomya*) *uchimuraensis kurodai* Kanno and Tanaka in Kanno et al., 1998: 22–25, figs. 9–10.
Akebiconcha chitanii (Kanehara).—Kanno and Ogawa, 1964: pl.1, figs. 17–18.
~ *Adulomya uchimuraensis* Kuroda.—Hayashi and Miura, 1973: pl. 1, fig. 15.
Cultellus izumoensis Yokoyama.—Katto and Masuda, 1978: pl. 3, figs. 8–9.
non Akebiconcha uchimuraensis Kuroda.—Matsumoto and Hirata, 1972: 755–757, pl. 1, figs. 1–8, pl. 2, figs. 1–2.

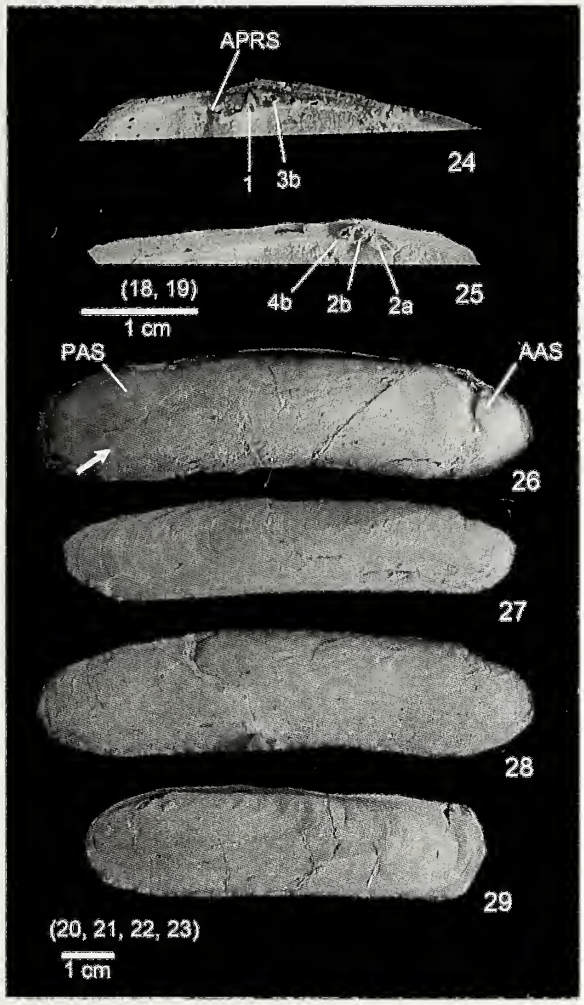
Material Examined: Fifty-three specimens were examined.

Remarks: Katto and Masuda (1978) illustrated two elongate specimens as *Cultellus izumoensis*. Our examination of the hinge of their illustrated specimen (Katto and Masuda, 1978: pl. 3, fig.9; Figures 15, 19 herein) indicates that they belong to *Adulomya uchimuraensis* for the following reasons: the left valve has an anterior (2a) and a middle cardinal (2b) tooth and a low posterior tooth (4b), and the right valve has only two teeth (cardinals 1, 3b); the anterior retractor scar is very deep, and some examined specimens show that the pallial line is entire (Figure 16). Such characteristics are never seen in any cultellid species. Cultellid species have only two protruded cardinal teeth in each valve and pallial sinus present.

Comparison: As discussed by Amano and Kiel (2011), *Adulomya uchimuraensis* can be separated from the early to middle Miocene *Adulomya chitanii* Kanehara, 1937 by its larger size and the lack of a pallial sinus. Although the maximum size of *Adulomya uchimuraensis* at Kii Oshima (94.1 mm long) is smaller than the maximum size of the specimens of *A. uchimuraensis* at its type locality in the Bessho Formation (180 mm; Amano and Kiel, 2011), it is still larger than *A. chitanii*, which reaches only up to 70.4 mm in length (Amano and Kiel, 2011).

Measurements: Left valve, length, 83.2 mm, height, 21.4 mm, WMNH-Ge-9; right valve, length, 89.7 mm, height, 17.8 mm, WMNH-Ge-10; right valve, length, 94.1 mm, height, 23.9 mm, WMNH-Ge-11.

Distribution: Lower Miocene Shikiya Formation in Wakayama Prefecture, lowest middle Miocene Takinoue Formation in Hokkaido and middle Miocene Bessho Formation in Nagano Prefecture.



Figures 24–29. *Adulomya uchimuraensis* (Kuroda), **24**, **26**, **28.** Right valve (WMNH-Ge-1120210293); **24**, rubber cast showing the hinge dentition and the anterior pedal retractor scar (APRS) of a right valve; **26**, rubber cast showing the anterior (AAS) and posterior adductor scars (PAS) in a right valve, white arrow indicates the posteriormost portion of the entire pallial line; **28**, rubber cast showing the outer surface of this shell. **25**, **29.** The specimen illustrated by Katto and Masuda (1978, pl. 3, fig. 9)(WMNH-Ge-1120210292); **25**, rubber cast showing details of the hinge area; **29**, left valve. **27.** Rubber cast of the outer surface of a right valve (WMNH-Ge-1120210290).

DISCUSSION

Recent studies on presumed Paleogene members of *Archivesica* from western North America (Amano and Kiel, 2007; Kiel and Amano, 2010) indicate that these species may not belong to *Archivesica* but instead to the genus *Pliocardia* or a related new genus (Amano and Kiel, 2012). Thus, the early Miocene *Archivesica sakoi* new species described here from southern Japan represents the oldest species of the genus *Archivesica*. However, this does not change our earlier observation that *Adulomya* was the dominant vesicomyid taxon during the early and middle Miocene in Japan because *Adulomya uchimuraensis* is far more common at the Kii Oshima site than *Archivesica sakoi*.

The association reported here from Kii Oshima consists almost exclusively of potentially chemosymbiotic bivalves (e.g., Taylor and Glover, 2010): dominant are the vesicomyids *Adulomya uchimuraensis* and *Archivesica sakoi* with a minor number of lucinids (*Lucinoma*? sp. and *Poumea*? sp.) and a solemyid (*Acharax* cf. *yokosukensis*). Such an association dominated by vesicomyid bivalves is typical for extant cold seep communities (Paull et al. 1985; Levin 2005; Majima et al. 2005; Campbell, 2006) and suggests that the Kii Oshima fauna might have lived at an ancient cold seep. Predatory gastropods such as the naticid *Euspira meisensis* found along with the chemosymbiotic bivalves are common in soft sediments in many marine environments, but they are also frequently found at ancient cold-seep communities, especially in the North Pacific realm (Amano et al. 2010; Kiel, 2010b). Due to the transported nature of the association and the lack of carbonate, the usual approach to identify an ancient cold-seep deposit by stable carbon isotope analysis (cf. Peckmann and Thiel, 2004) is not possible. This is so far the only record of a vesicomyid-dominated faunule from the Shikiya Formation and from southern Honshu (cf., Majima et al. 2005).

Only about 4 km west of the Kii-Oshima locality, a hydrocarbon-seep fauna has been recently been reported by the present authors from the upper Eocene to lower Oligocene(?) Tanamigawa Formation at Tanosaki (Amano et al., 2013). That Paleogene community differs from the early Miocene fauna from Kii Oshima reported here by consisting of a different vesicomyid genus (*Hubertschenckia*), the bathymodiolin mussel *Bathymodiolus*, the thyasirid bivalve *Conchocele* and the absence of lucinids. As already pointed out by Amano et al. (2013), Paleogene seep communities in Japan generally lack lucinid bivalves, while lucinids are generally present at Miocene seep communities as in the the Kii Oshima fauna reported here.

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LITERATURE CITED

Amano, K. and R.G. Jenkins. 2011. Fossil records of extant vesicomyid species from Japan. Venus 69: 163–176.

Amano, K and S. Kiel. 2007. Fossil vesicomyid bivalves from the North Paeific region. The Veliger 49: 270–293.

Amano, K and S. Kiel. 2010. Taxonomy and distribution of fossil *Archivesica* (Bivalvia: Vesicomyidae) in Japan. The Nautilus 124: 155–165.

Amano, K and S. Kiel. 2011. Fossil *Adulomya* (Vesicomyidae, Bivalvia) from Japan. The Veliger 51: 76–90.

Amano, K and S. Kiel. 2012. Two Neogene vesicomyid species (Bivalvia) from Japan and their biogeographic implications. The Nautilus 126: 79–85.

Amano, K., R.G. Jenkins, M. Aikawa, and T. Nobuhara, 2010. A Miocene chemosynthetic community from the Ogaya Formation in Joetsu: evidence for depth-related ecologic control among fossil seep communities in the Japan Sea back-arc basin. Palaeogeography, Palaeoclimatology, Palaeoecology, 286: 164-170.

Amano, K., R. G. Jenkins, Y. Sako, M. Ohara and S. Kiel. 2013. A Paleogene deep-sea methane-seep community from Honshu, Japan. Palaeogeography, Palaeoclimatology, Palaeoecology 387: 126–133.

Audzijonyte, A., E.M. Krylova, H. Sahling, and R.C. Vrijenhoek. 2012. Molecular taxonomy reveals broad trans-oceanic distributions and high species diversity of deep-sea clams (Bivalvia: Vesicomyidae: Pliocardiinae) in chemosynthetic environments. Systematics and Biodiversity 10: 403-415.

Campbell, K.A. 2006. Hydroearbon seep and hydrothermal vent paleoenvironments and paleontology: Past developments and future research directions. Palaeogeography, Palaeoclimatology, Palaeoecology 232: 362-407.

Dall, W.H. 1891. Scientific results of explorations by the U.S. Fish Commission Steamer Albatross. XX. On some new or interesting West American shells obtained from dredgings of the U.S. fish eommission steamer Albatross in 1888. Proceedings of the U.S. National Museum 14: 174–191.

Dall, W.H. 1896. Diagnoses of new species of mollusks from the west coast of America. Proceedings of the U.S. National Museum of Natural History 18: 7–20.

Dall, W.H. 1908. Reports on the dredging operations off the west coast of Central America ... The Mollusca and Brachiopoda. Bulletin of the Museum of Comparative Zoology at Harvard University 43: 205–487.

Dall, W.H. and C.T. Simpson. 1901. The Mollusea of Porto Rico. Bulletin of the United States, Fish and Fisheries Commission 20: 351–524.

Hayashi, T. and Y. Miura. 1973. The Cenozoic sediments in the southern part of Okazaki City, central Japan. Bulletin of the Aichi University of Education 22: 133–149 [in Japanese with English abstract].

Hisatomi, K. 1981. Geology and sedimentology of the Kumano Group in the southeastern part of the Kumano basin, Kii Peninsula. Journal of Geological Society of Japan 87: 157–174 [in Japanese with English abstract].

Kanehara, K. 1937. Miocene shells from the Joban coal-field. Bulletin of the Imperial Geological Survey of Japan 27: 1–12.

Kanie, Y. and T. Kuramochi. 1995. *Acharax yokosukensis*, n. sp. (gigantic Bivalve) from the Miocene Hayama Formation of the Miura Peninsula, south-central Japan. Seience Report of Yokosuka City Museum 43: 51–57.

Kanno, S. and H. Ogawa. 1964. Molluscan fauna from the Momijiyama and Takinoue districts, Hokkaido, Japan. Science Reports of the Tokyo Kyoiku Daigaku, Section C 8: 269–294.

Kanno, S., K. Tanaka, H. Koike, K. Narita, and T. Endo. 1998. *Adulomya uchimuraensis* Kuroda (Bivalvia) from the Miocene Bessho Formation in Shiga-mura, Nagano Prefeeture, Japan. Research Report of the Shinshushinmaehi Fossil Museum 1: 17–28.

Katto, J. and K. Masuda. 1978. Tertiary Mollusca from the southern part of Kii Peninsula, Wakayama Prefecture, Southwest Japan. Research Report of Kochi University, Natural Science 27: 97–111.

Kiel, S. 2010a. The fossil record of vent and seep mollusks. In, Kiel, S. (ed.). The vent and seep biota, Topics in Geobiology 33: 255–277.

Kiel, S. 2010b. On the potential generality of depth-related ecologie structure in cold-seep communities: Cenozoic and Mesozoic examples. Palaeogeography, Palaeoclimatology, Palaeoecology 295: 245–257.

Kiel, S. and K. Amano. 2010. Oligocene and Mioeene vesicomyid bivalves from the Katalla district in southern Alaska, USA. The Veliger 51: 76–84.

Kuroda, T. 1931. Fossil Mollusca. In: Homma, F. (ed.). Geology of the central part of Shinano, part 4. Kokin Shoin, Tokyo: 1–90 [in Japanese].

Kuroda, T. 1943. *Akebiconcha*, a new pelecypod genus. Venus 13: 14–18. [in Japanese with English description].

Levin, L.A. 2005. Ecology of cold seep sediments: interactions of fauna with flow, ehemistry and microbes. Oceanography and Marine Biology Annual Review 43: 1–46.

Makiyama, J. 1926. Tertiary fossils from north Kankyo-do, Korea. Memoirs of College of Science, Kyoto Imperial University, Series B 2: 143–160.

Majima, R., T. Nobuhara, and T. Kitazaki, 2005. Review of fossil chemosynthetic assemblages in Japan. Palaeogeography, Palaeoclimatology, Palaeoecology 227: 86–123.

Matsumoto, E. and M. Hirata. 1972. *Akebiconcha uchimuraensis* (Kuroda) from the Oligocene formations of the Shimanto terrain. Bulletin of the National Science Museum, Tokyo 15: 753–760.

Okutani, T. and B. Métivier. 1986. Description of three new species of vesieomyid bivalves colleeted by the submersible Nautile from abyssal depths off Honshu, Japan. Venus 45: 147–160.

Paull, C.K., A.J.T. Jull, L.J. Toolin, and T. Linick. 1985. Stable isotope evidence for chemosynthesis in an abyssal seep community. Nature 317: 709–711.

Peckmann, J. and V. Thiel, 2004. Carbon cycling at aneient methane-seeps. Chemical Geology 205: 443–467.

Sasaki, T., T. Okutani, and K. Fujikura. 2005. Molluscs from hydrothermal vents and cold seeps in Japan: A review of taxa recorded in twenty reeent years. Venus 64: 87–133.

Scarlato, O.A. 1981. Bivalve molluses from the middle latitude of the western part of the Pacific Ocean. Taxonomic Monograph of Fauna USSR 126: 1–479 [in Russian].

Takeda, H. 1953. The Poronai Formation (Oligoeene Tertiary) of Hokkaido and South Sakhalin and its fossil fauna. Studies on Coal Geology, the Hokkaido Association of Coal Mining Technologists 3: 1–103.

Tanaka, K. 1959. Molluscan fossils from central Shinano, Nagano Prefecture, Japan (Part 1)—fossils from Akanuda

limestone. Journal of Shinshu University, Faculty of Education 8: 115–133.
Tanaka, K. 1960. Illustrated Cenozoic fossils, 31. On *Adulomya* from the Bessho Formation and *Anadara* from the Ogawa Formation. Cenozoic Research 31: 783– 787.
Taylor, J.D. and E.A. Glover. 2010. Chemosynthetic bivalves. In: Kiel, S. (ed.). The vent and seep biota. Topics in Geobiology. Springer, Heidelberg, pp. 107–136.
Woodring W.P. 1925. Miocene mollusks from Bowden, Jamaica. Part I: Pelecypods and Scaphopods. Carnegie Institution of Washington, Publication 366: 1–222.

On the authorship and primary type of *Cerion incanum* (Gastropoda: Cerionidae)

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ABSTRACT

Although the author of the species *Cerion incanum* (originally proposed as *Pupa incana*) has been cited as Binney, 1851, a review of his multiple uses of the name do not satisfy the criteria of availability set forth by the International Code of Zoological Nomenclature (Article 12), until the publication of illustrations of three shells labelled *Pupa incana* in 1857. In a separately authored paper published as part of Binney's multivolume work on the Terrestrial Mollusks of the United States, Leidy published detailed descriptions and illustrations of several organ systems of *Pupa incana* in 1851. Thus, the authorship of *Pupa incana* must be attributed to Leidy, 1851, rather than to Binney. As Leidy did not retain the dissected tissues, there is no surviving type material for *Pupa incana* Leidy. A neotype is designated for *Pupa incana* Leidy, 1851, from the subsequently designated type locality in order to provide an objective standard of reference for this species-group taxon that may be used to evaluate the relationship of the nominotypical subspecies to three subsequently described subspecies, as well as to two introduced Bahamian species with which it is documented to have hybridized.

Additional Keywords: Pupa incana, authorship, neotype, Florida Keys

INTRODUCTION

The family Cerionidae is well known for its remarkable morphological diversity and large number of taxa, particularly in the recent faunas of Cuba and the Bahamas. In contrast, this family is represented in the Florida Keys by a single native species. The authorship of this species, *Cerion incanum* (originally proposed as *Pupa incana*), has universally been attributed to Binney, 1851 (e.g., Maynard, 1889; Pilsbry, 1902; Bartsch, 1920; Abbott, 1989), despite recognition by several subsequent authors of difficulties with the manner in which it was published (e.g., W. G. Binney, 1859: 142; Clench, 1957: 148; Pilsbry, 1946: 162).

A review of Amos Binney's posthumously published work (Binney, 1851–57) in the context of the requirements of the International Code of Zoological Nomenclature (ICZN, 1999) reveals that his uses of the name *Pupa incana* do not occur in a way that satisfies the criteria of availability (Article 12) until the publication of plate 68 (Binney, 1857), which associates images of two adult and one juvenile shell with the name *Pupa incana* (Article 12.2.7, ICZN, 1999: 17). The first usage of the name *Pupa incana* in conjunction with a description and illustrations was in a portion of the work written by Joseph Leidy (Leidy, 1851) reporting on the anatomy of several terrestrial gastropods. Thus, the authorship of this species must be attributed to Leidy, 1851. Leidy's description pre-dates the publication of *Pupa detrita* Pfeiffer, 1854, which is a junior synonym of *Pupa incana* Leidy, 1851, but a senior synonym of *Pupa incana* Binney, 1857.

HISTORICAL REVIEW

Amos Binney, M.D. (1803–1847), a physician, businessman, and naturalist had an avid interest in the terrestrial Mollusca of North America, accumulated a sizeable collection, and had undertaken the production of a major publication on the subject. Despite his untimely death (February 18, 1847), he had made provisions for the completion and publication of this work in his will. Augustus A. Gould was engaged by the executors of Binney's estate to edit and publish this work. Gould (in Binney, 1851a: ix–x) reported that "The work was found to be less complete than anticipated ..." and acknowledged that there are some discrepancies between the first volume and the second, portions of which were written by Gould (clearly identified by 'annexation of the letter "G."')

The work, titled *The Terrestial Air-Breathing Mollusks of the United States, and the Adjacent Territories of North America*, was published in five volumes, the first three attributed to A. Binney (1851–1857) although

edited by A. A. Gould. The first volume (1851) contains a series of essays by Amos Binney on topics ranging from the history of zoological investigations in America to the zoogeography and ecology of terrestrial Mollusca, and also includes a section, authored by Joseph Leidy, on the anatomy of the terrestrial gastropods of the United States. The systematic treatment of taxa begins in the second volume (1851) and continues into the third volume (1957), which also contains the plates illustrating the treated species. The fourth and fifth volumes were authored by W. G. Binney (1859–1878), the son of Amos Binney, and are a continuation and expansion of the first three volumes. W. G. Binney further continued his work on this fauna, publishing three supplements to the fifth volume (Binney, 1883; 1886; 1890).

Chronological appearance of the name *Pupa incana* in *The Terrestial Air-Breathing Mollusks of the United States, and the Adjacent Territories of North America*

Volume 1

Pupa incana Binney, 1851a: 109 (*nomen nudum*). The name appears in a "Table of Distribution of Species in Several Geographic Regions," listing *Pupa incana* as one of the "Species noticed in the Atlantic Region Only".

Pupa incana Binney, 1851a: 119 (*nomen nudum*). *Pupa incana* is listed as among the land mollusks that are indigenous to Cuba but also occur in southern Florida.

Pupa incana Binney, 1851a: 128 (*nomen nudum*). *Pupa incana* is listed in a table as one of the species in "Section 1." Identified on page 108 as occurring on "*The Peninsula of Florida*". The species name is not italicized in the table, indicating that it is not "introduced from foreign countries" (see p. 126).

Pupa incana Binney, 1851a: 153 (*nomen nudum*). *Pupa incana* is listed as one of the species "undoubtedly from Cuba", transported on floating debris, that has flourished in southern Florida.

Pupa incana Binney, 1851a: 162 (*nomen nudum*). *Pupa incana* is listed in a "Table of Distribution of Species Inhabiting the United States, in other parts of America" indicating that it also occurs in Cuba.

Pupa incana Leidy, 1851: 199 (*nomen nudum*). *Pupa incana* appears in a list of animals dissected.

Pupa incana Leidy, 1851: 216 (*nomen nudum*). The name appears ("In *Vaginulus*, *Pupa incana*, etc.") in a description of the "tissues of the digestive apparatus". This is a generalized description that does not distinguish *Pupa incana* from *Vaginulus*.

Pupa incana Leidy, 1851: 230–231. A detailed description of the genital apparatus of *Pupa incana* is provided. This is the first association of the name *Pupa incana* with a description (of the reproductive system) that meets the requirements of Article 12.1 (ICZN, 1999:16), making the name *Pupa incana* available as *Pupa incana* Leidy, 1851.

Pupa incana Leidy, 1851:259. *Pupa incana* appears in captions to figures ii–iv of plate 15, as well as on the plate itself. This plate includes three illustrations of the dissected soft tissues (Article 12.2.7; ICZN, 1999:17), making the name *Pupa incana* available.

Volume 2

Gould in Binney, 1851b: 314. Uses the binomen *Pupa incana* in a discussion of supraspecific relationships within *Pupa*. The annotation "[G.]" identifies this as the work of Gould.

Gould *in* Binney, 1851b:316–319. This description was no doubt intended by Binney to be the formal description of *Pupa incana*. However, Gould replaced the name with *Pupa maritima* Pfeiffer. The following parenthetical note, identified as being by Gould [-G.] follows the description.

[This shell was described by Dr. Binney as a new species, and is referred to in the first volume under the name, *P. incana*; and the plate representing it is so lettered; but it is so evidently the *P. maritima* of Dr. Pfeiffer that it would be deviating from scientific rules to introduce it under any other name. It is most likely that *P. cyclostoma*, Küster, is merely a small specimen of this species, its variation in size being very considerable. -G.]

Volume 3

Gould in Binney, 1857: 39. "Index to Plates" says "*Pupa maritima* Pfeiffer" with a note that the plate itself is lettered *Pupa incana*.

Binney, 1857: pl. 68. Plate illustrating two adult and one juvenile specimen is labeled *Pupa incana*. This makes the taxon *Pupa incana* Binney available (Article 12.2.7; ICZN, 1999:17) as of 1857.

Volume 4

Binney, W.G., 1859: 142. W. G. Binney commented "In 1851, this species was only designated by name in vol. i; the full description was given in vol. ii, the name being changed by Gould to *P. maritima*. Shuttleworth's description of *detrita* has not priority over the name I have retained [*P. incana*]."

Binney, W.G., 1859: 206, pl. 79, fig. 17. The subspecies *Pupa incana fasciata* is introduced in the "Explanation of the Plates" for a variety from Key Biscayne, Florida.

Volume 5

Binney, W.G. 1878: 213. Included the note "*Pupa incana*, = *Strophia*"

Binney, W.G. 1878: 220–222, figs. 125,126. A synonymy and description of the shell, jaw and anatomy of *Strophia incana* is provided.

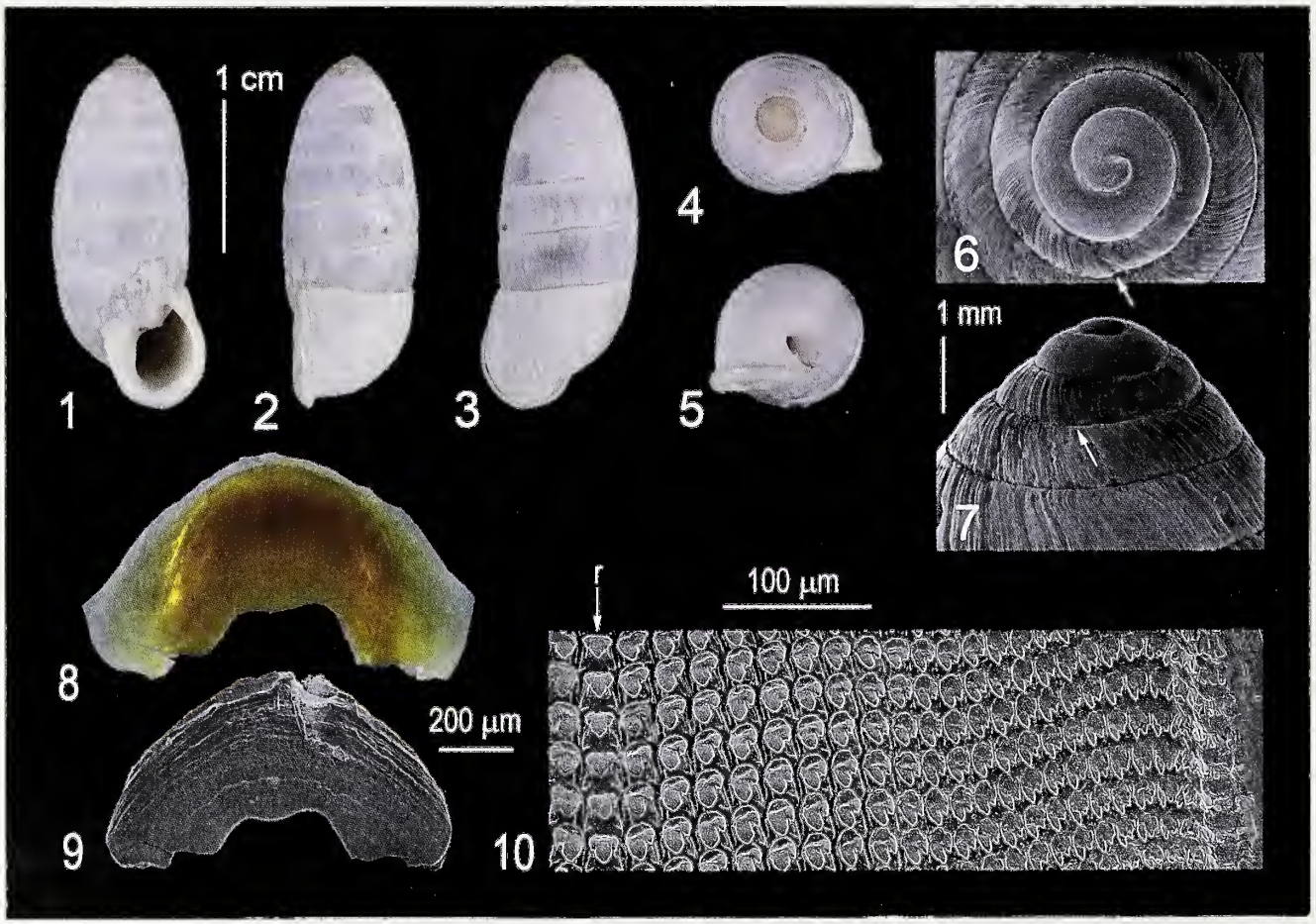
TYPE MATERIAL

It is not clear if Leidy's descriptions of several organ systems of *Pupa incana* were based on one or multiple dissected specimens. It is probable that the shell(s) were crushed in order to access the soft tissues, and the anatomical material was not saved following dissection. Thus, there is no surviving type material for Leidy's taxon.

Gratacap (1901) reported that the Binney and Bland collection of North American land shells, which included specimens used by Amos Binney and A. A. Gould in the preparation of *Terrestrial Air-Breathing Mollusks of the United States*, as well as specimens that W. G. Binney incorporated from his collection and from the cabinet of Thomas Bland, came to the American Museum of Natural History in 1882. In the published catalog of this collection, Gratacap (1901: 369) listed ten lots of *Strophia incana* [= *Cerion incanum* = *Pupa incana*], from Florida, Key Biscayne, and Key West. Among these, he refers to two lots [Cat. Nos. 795, 796] as "Type", citing the pagination for the description "(as *maritima* Pfeiff.)" and referencing the plate published in 1857, illustrating two adult specimens and a juvenile over the name *Pupa incana*. A specimen in the collections of the Museum of Comparative Zoology (MCZ 149431) is also catalogued as a syntype of *Pupa incana* Binney, 1851.

However, these specimens were not seen by Leidy. As neither the description (as *maritima*) nor the illustrations of these shells were published until after Leidy's anatomical descriptions, they cannot be considered as part of a syntype series of *Pupa incana* Leidy, 1851 (Article 73.2.1, ICZN, 1999: 81). Thus, there are no name-bearing type specimens of *Pupa incana* Leidy, 1851.

Early authors regarded the geographic range of *Cerion incanum* to span Cuba, the Bahamas, and southern Florida, both the mainland and the Keys. Pilsbry (1902:



Figures 1–10. *Pupa incana* Leidy, 1851. Neotype, USNM 1231355. Little Hamaca City Park, Government Road, Key West, Florida, 24°33.410′ N, 81°46.370′ W. In roadside leaf litter, under rock, at base of grass clumps. February 8, 2013. M.G. Harasewych coll. **1–5.** Shell. **1.** Apertural, **2.** Lateral, **3.** Dorsal, **4.** Apical, and **5.** Basal views. **6–7.** Scanning electron micrographs of protoconch. **6.** Apical, and **7.** Lateral views. Arrows indicate protoconch/teleoconch transition. **8–9.** Dorsal views of jaw. **8.** Photomicrograph. **9.** Scanning electron micrograph. **10.** Scanning electron micrograph of portion of radular ribbon. Entire radula consists of 135 rows, each row with formula 24-1-24. r, rachidian tooth.

214) restricted the type locality of *Cerion incanum* to the area around the salt ponds on Key West. Subsequent workers further subdivided this species into subspecies. W.G. Binney (1859) proposed the variety *Pupa incana fasciata* for a form from Key Biscayne, Florida. Pilsbry and Vanatta (1899) added *Cerion incanum saccharimeta* from Sugarloaf Key, and Pilsbry (1902) described *Cerion incanum vaccinum* from Key Vaca.

A **neotype** for *Pupa incana* Leidy, 1851, is designated from a population [Little Hamaca City Park, Government Road, Key West, Florida, 24°33.410′ N, 81°46.370′ W] inhabiting the edges of salt ponds in Key West, Florida that corresponds to the type locality reported by Pilsbry. This neotype (USNM 1231355) consists of 2.0 protoconch whorls and 8.5 teleoconch whorls (Figures 1–7), has a shell length of 24.18 mm, a shell width of 9.47 mm, and a maximum aperture length of 6.64 mm. It corresponds to the *Cerion incanum incanum* of authors, and generally conforms to Leidy's anatomical descriptions (although Pilsbry 1946: 162, noted some inaccuracies in Leidy's description of the pallial organs) as well as to the numerous detailed subsequent descriptions of the anatomy and shell morphology (e.g, W. G. Binney, 1878: 220; Bartsch, 1920: 7; Pilsbry, 1902: 213; 1946: 160–165).

A neotype is necessary in order to provide an objective standard of reference for this species group taxon that may then be used to evaluate the relationships of the nominotypical subspecies to three subsequently described subspecies that are native to Florida. A precisely defined concept of *Cerion incanum incanum* is of particular importance in unravelling the relationships of this species to several species that have been purposely introduced into the Florida Keys from the Bahamas and elsewhere during the early 20th century (see Bartsch, 1920; Pilsbry, 1946; Harasewych and Strauss, 2006), as some of these have been documented as having hybridized with *Cerion incanum* (Woodruff and Gould, 1987).

In addition to the shell, radula, and jaw, genomic DNA samples have been archived for this neotype. Results of Next Generation sequencing of a subsample of this DNA, including the reconstruction of a complete mitochondrial genome and the complete ribosomal operon, will be published separately.

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LITERATURE CITED

Abbott, R. T. 1989. Compendium of Landshells. American Malacologists, Melbourne, 240 pp.

Bartsch, P. 1920. Experiments in the breeding of Cerions. Papers of the Department of Marine Biology, Carnegie Institution of Washington 14 (282): 1–54, pls. 1–59.

Binney, A. 1851–1857. [published posthumously]. The Terrestial Air-Breathing Mollusks of the United States, and the Adjacent Territories of North America: Described and Illustrated by Amos Binney. Edited by Agustus A. Gould. Charles Little and James Brown, Boston, Volume 1 [1851a]:i–xxix, 1–266 [last page misnumbered as 366 (typo)] pls. 1–16; Volume 2 [1851b]: 1–362; Volume 3 [1857]: 1–40, pls. 1–74.

Binney, W.G. 1859–1878. The Terrestial Air-Breathing Mollusks of the United States, and the Adjacent Territories of North America. Volume 4 [1859] [published in the Boston Journal of Natural History, vol. 2]: i–viii, 1–207, pl. 75–80; Volume 5 [1878] [published in the Bulletin of the Museum of Comparative Zoology vol. 4]: i–iv, 1–449, pls.1–16.

Binney, W.G., 1883. A Supplement to the Fifth Volume of The Terrestrial Air-Breathing Mollusks of the United States, and the Adjacent Territories of North America. Bulletin of the Museum of Comparative Zoology 11 (8): 135–166, pls. 1–4.

Binney, W.G., 1886. A Second Supplement to the Fifth Volume of The Terrestial Air-Breathing Mollusks of the United States, and the Adjacent Territories of North America. Bulletin of the Museum of Comparative Zoology 13 (2): 23–48, pls. 1–3.

Binney, W.G., 1890. A Third Supplement to the Fifth Volume of The Terrestial Air-Breathing Mollusks of the United States, and the Adjacent Territories of North America. Bulletin of the Museum of Comparative Zoology 19 (4): 183–226, pls. 1–11.

Clench, W.J. 1957. A catalog of the Cerionidae (Mollusca: Pulmonata). Bulletin of the Museum of Comparative Zoology 116: 121–169.

Grataeap, L.P. 1901. Catalogue of the Binney and Bland Collection of Terrestrial Air-Breathing Mollusks of the United States and Territories in the American Museum of Natural History, with enumeration of types and figured specimens, and supplementary notes. Bulletin of the American Museum of Natural History 14 (Article 23): 335–403.

Harasewych, M.G. and J. Strauss. 2006. A new record of introduced Cerion (Gastropoda: Pulmonata: Cerionidae) in southeastern Florida. The Nautilus 120: 94–100.

ICZN (International Commission on Zoological Nomenclature) 1999. International Code of Zoological Nomenclature, Fourth Edition. The International Trust for Zoological Nomenclature, London, 306 pp.

Leidy, J. 1851. Special Anatomy of the Terrestrial Gastropoda of the United States. pp.198–260, pls. 1–16. [In] Binney, A. 1851a. The Terrestrial Air-Breathing Mollusks of the United States, and the Adjacent Territories of North America: Described and Illustrated by Amos Binney. Edited by Augustus A. Gould. Volume 1: 1–266, pls. 1–16.

Maynard, C.J. 1889. Monograph of the Genus *Strophia*. [continued]. Contributions to Science 1(2): 68–79, pl. 7.

Pilsbry, H.A. 1902. Family Cerionidae. Manual of Conchology. Series 2. Pulmonata. Academy of Natural Sciences of Philadelphia 14(56): 193–286, pls. 27–47.

Pilsbry, H.A. 1946. Family IX.Cerionidae. Land Mollusca of North America. Academy of Natural Sciences of Philadelphia, Monographs 3, 2(1): 158–169.

Pilsbry, H.A. and E.G. Vanatta. 1899. Some Cuban species of Cerion. Proceedings of the Academy of Natural Sciences of Philadelphia [1898]: 475–478, figs. 1–9.

Woodruff, D.S. and S.J. Gould. 1987. Fifty years of interspecific hybridization: genetics and morphometrics of a controlled experiment on the land snail *Cerion* in the Florida Keys. Evolution 41: 1022–1045.

The freshwater mussel collection (Bivalvia: Unionida) of the Museo Nacional de Ciencias Naturales (Madrid, Spain)

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ABSTRACT

A review of the freshwater mussel collection housed at the Museo Nacional de Ciencias Naturales of Madrid (Spain) (MNCN) including complete specimen data for the 3,270 lots is provided. The 10,009 specimens (single valves not included) represent species from five continents and Oceania, with 342 species in 110 genera belonging to 6 currently recognized families of the Order Unionida. This collection contains 42.9 % and 60.7 % of the total currently recognized unionoid species and genera respectively. There are 152 lots with 30 species from Africa, 1,359 lots containing 245 species from the Americas, 125 lots including 55 species from Asia, 1,472 lots representing 18 European species and 28 lots of 7 species from Oceania. The Iberian Peninsula has the greatest representation with 1,233 lots (114 Margaritiferidae and 1,119 Unionidae). The alcohol-preserved collection includes 456 lots of European and 39 lots of North African mussels, and represents a significant contemporary collection of freshwater mussels from these areas. We also present an historic description of the collection, with special emphasis on the South and Central American mussels collected by the Comisión Científica del Pacífico (1862–1866), and updated data on the presence of threatened and endangered species following the Endangered Species Act (USA) and the Habitats Directive (Europe). According to the International Union for the Conservation of Nature [IUCN] Red List, there are 30 % of the Vulnerable species, 36 % of the Endangered species, 44.5 % of the Critically Endangered and the 34.5 % of today's Extinct freshwater mussels represented.

INTRODUCTION

Biological specimen collections, conserved in natural history museums and other institutions, provide a rich source of data essential for numerous areas of research including biogeography to phenological or evolutionary studies. These collections comprise samples collected during the period of accelerated anthropogenic habitat destruction, climate warming and freshwater habitat destruction. These specimens and their associated data, document baseline conditions before the major impact of these factors (Nicholson, 1991; Allmon, 1994; Shaffer, Fisher and Davidson, 1998; Lister et al., 2011; Suárez and Tsutsui, 2004). Museum collections are essential for the future documentation of the abundance and distribution of species (Lips, 2011). In order to achieve this goal, it is necessary to curate existing specimens and their corresponding data in museums and make sure this data is well organized and available for scientists (Solem at al., 1981) and others on the World Wide Web.

The objective of this paper is to update the data associated with each lot (taxonomic, faunistic, storage, number of specimens, etc.) in the freshwater mussel collection (order Unionida) (Bouchet and Rocroi, 2010; Carter et al., 2011) of the Museo Nacional de Ciencias Naturales (Madrid, Spain) (MNCN), providing a comprehensive overview of this material, as well as documenting the association of classic studies on taxonomy and distribution with the specimens. Dry specimens may be used for studies on shell ultrastructure, trace element analyses, sclerochronology or climate change, while alcohol-preserved specimens can be the source of anatomical and molecular markers used in systematic, phylogenetic or evolutionary research. We present an

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historical description of this collection, with special emphasis on the freshwater mussels collected by the "Comisión Científica del Pacífico", a natural history expedition made between 1862 and 1866, and provide updated data on the presence of Threatened, Endangered and Extinct species following the IUCN Red List, the United States Endangered Species Act and the Habitats Directive.

The mollusk collection of the MNCN houses around 100,000 lots of the eight known mollusk classes: Solenogastra, Caudofoveata, Polyplacophora, Monoplacophora, Gastropoda, Cephalopoda, Bivalvia, and Scaphopoda. Although specimens have been collected from around the world, the best represented areas are the Iberian Peninsula, Philippines, Cuba, Equatorial Guinea, and South America. The terrestrial mollusk collections from the Philippines, Cuba and Equatorial Guinea are probably among the best in the world. There is an important historical representation of the South and Central American fauna coming from the Comisión Científica del Pacífico.

The core historical material of the collection is from three Spanish malacologists: Paz (P. M. Paz y Membiela, 1808–1874) with 40,000 specimens representing 12,000 species and subspecies, Hidalgo (J. González Hidalgo, 1839–1923) with 8,000 species, and Azpeitia (F. Azpeitia, 1859–1934) with 80,000 specimens of 8,171 species (6,594 gastropods and 1,577 bivalves) (Barreiro, 1992). Other historical material comes from the founder of the Museum, P. Franco Dávila (1711–1786), and from M. Graells (1809–1898), who was director of the museum between 1845 and 1867. More recently, the collections have grown with the additions of A. Ortiz de Zárate (1887–1964) with 4,500 lots, A. Cobos (1922–1998) with 4,390 lots, and J. Conde with approximately 20,000 lots. The type collection including primary and secondary types, contains 1,192 lots corresponding to 946 taxa, all are computerized, arranged in taxonomic order, and housed in all steel cabinets with metal drawers that meet conservation standards and are locked (Templado et al., 1993; Villena et al., 1997). Currently, only 50% of the general collection is computerized.

The Comisión Científica del Pacífico (the Comisión) collected 38,755 specimens belonging to 816 different species (Almagro, 1866). Most of them were collected by the President of the Comisión, (P. M. Paz y Membiela), and by F. P. Martínez y Saez, but other members of the expedition like Jiménez de la Espada, Isern and Almagro also collected mollusks. Zameron, Barreiros, Philippi and Richardson donated 767 specimens of 43 species, and 37 specimens of 19 species were purchased (Almagro, 1866). All of the Comisión specimens were studied by Martínez y Saez, who was responsible for mollusks during the expedition, and by J. González Hidalgo (Hidalgo, 1900; Calvo, 1994). Martinez y Saez and Hidalgo wrote the three volumes set *Moluscos del viaje al Pacífico*, which included marine bivalves (Martínez, 1869), terrestrial gastropods (Hidalgo, 1872) and marine gastropods (Hidalgo, 1879). The freshwater bivalves were studied by Isaac Lea (1792–1886) (Lea, 1866a, b, 1867, 1869a, b) and Fritz Haas (Haas, 1886–1969), who published "*Náyades del viaje al Pacífico*" (Haas, 1916).

Of the 60 new mollusk species described from the material collected by the Comisión, 18 were freshwater bivalves: 2 were described by Hidalgo (Calvo, 1994), 14 by Lea (1866a, b, 1867, 1869a, b) and 2 by Haas (1916). The 14 species described by Lea (1866a, b, 1867, 1869a, b) lacked exact locality data, reporting only South or Central America, but were probably collected by Paz in the Uruguay River (Salto Oriental, Uruguay) and were sent to Lea at the end of the expedition (Haas, 1916). It was uncertain if Lea's types were included in the MNCN or in the Lea collection at the USNM (Smithsonian Institution, Washington, DC) (Haas, 1916).

RESULTS

Detailed locality, taxonomic and historical on all the freshwater mussel (Unionida) lots in the MNCN collection can be found at the Global Biodiversity Information Facility (GBIF). There are 10,009 specimens (single valves not included) in 3,270 lots representing 342 species of 110 genera belonging to the currently recognized 6 families: Margaritiferidae, Unionidae, Mycetopodidae (= Mulleriidae), Etheriidae, Iridinidae and Hyriidae (Bouchet and Rocroi, 2010; Carter et al., 2011). The collection contains representative lots and specimens of 60.7 % and 42.9 % of the total number of described unionoid genera and species respectively (Graf and Cummings, 2007; Bogan, 2008) (Table 1). There are 587 alcohol-preserved lots and 2,683 dry lots. Among these specimens are glochidia, optical microscopical slides of soft parts and shell thin sections.

Summarizing the geographical information on specimens in the unionoid collection (Table 2), there are 134 lots without locality information, including the continent of origin. The area represented by the most specimens is Europe, with 18 species (including the exotic *Sinanodonta woodiana* (Lea, 1834)) in 1,472 lots, and 29 lots without country identification. The largest number of lots comes from the Iberian Peninsula, with 1,233 lots (114 Margaritiferidae and 1,119 Unionidae): 1,131 from Spain and 102 from Portugal. During the past 12 years (Soriano et al., 2001), the Iberian material in the family Unionidae in the collection has grown by 754 lots. Other European lots by country are: Albania (3), Austria (7), Belgium (11), England (14), Croatia (6), Czech Republic (1), Denmark (1), Estonia (2), France (69), Finland (1), Germany (37), Greece (32), Hungary (7), Ireland (5), Italy (58), Latvia (2), Netherlands (1), Poland (11), Romania (2), Russia (12), Slovakia (10), Slovenia (4) and Switzerland (5). Of the 152 African lots, 42 come from Morocco, 19 from Egypt, 18 from Senegal and 18 from Tunisia; the rest come from Algeria (1), Burkina Faso (3), Burundi (7), Democratic Republic

Table 1. Total number of genera and species in families of freshwater mussels in the MNCN collection in comparison with the whole described taxa. * We consider all the living Margaritiferidae belonging to the genus *Margaritifera*. (1) Graf & Cummings (2007). (2) Bogan (2008).

	Species MNCN	Genera MNCN	Described species (1)	Described species (2)	Described genera (2)
Etheriidae	1	1	4	1	1
Hyriidae	34	9	71	83	17
Iridinidae	12	6	43	41	6
Margaritiferidae	7	1*	12	12	3
Mycetopodidae	24	7	36	39	12
Unionidae	264	86	674	621	142
TOTAL	342	110	840	797	181

of the Congo (6), Ethiopia (1), Gabon (1), Guinea (1), Ivory Coast (2), Libya (2), Mauritania (1), Niger (1), Nigeria (1) and South Africa (6). The alcohol-preserved collection, with 456 European and 39 lots of North African naiads is one of the most significant contemporary collections of freshwater mussels for these areas. There are 1,358 American lots, which include 973 from the United States of America, and 53 lots from Cuba, 44 collected by Poey already included in the Paz y Membiela collection (Barreiro, 1992), and the aforementioned specimens collected by the Comisión Científica al Pacífico (see below). The number of lots by country is: Argentina (14), Bolivia (4), Brazil (60), Canada (2), Chile (17), Colombia (2), Ecuador (18), Guatemala (1), Mexico (10), Nicaragua (8), Paraguay (1), Peru (3), Uruguay (103) and Venezuela (1). There are 78 North American lots without a country listed. The best represented Asiatic countries, with a total of 125 lots, are Japan with 33 and China with 21. Other Asiatic lots by country are: Cambodia (1), Philippines (8), India (15), Indonesia (5), Iraq (6), Israel (2), Laos (3), Malaysia (1), Myanmar (2), Singapore (2), Sri Lanka (2), Taiwan (1), Thailand (7), Turkey (9) and Vietnam (7). There are 28 lots from Oceania, 8 from Australia and 20 from New Zealand.

HISTORICAL OVERVIEW

Among the freshwater mussel historical material, it is important to document the presence of mid-nineteenth century specimens collected in South America by the Comisión Científica al Pacífico (1862–1866), which included the Paraná and Amazon basins, Chile and the Pacific coast of Ecuador. The information about these specimens comes from three different sources: (1) Almagro (1866, page 162) published the list of the freshwater mussels collected in the Comisión, detailing the localities (15), number of species (44), number of specimens (300) and the name of the collectors. (This information was based on specimens exhibited after the Comisión Expedition); (2) Lea (1866a, b; 1867, 1869a, b) described 14 new species from South America, procured by Paz during the Comisión but failed to include any reference as to the origin of the specimens. Following Lea (1866a), some of the material sent by Paz was preserved in alcohol; (3) Haas (1916), who, during his obliged stay in Spain due to the unfavorable political climate in Germany (Haas, 1915), was invited to the MNCN where he studied the mussels collected during the Comisión. Haas (1916) listed 32 different taxa from the Comisión collection, two he described as new species (*Diplodon hidalgoi* and *Mycetopoda bolivari*). He added a summary organizing the species by river basin and included some biogeographic remarks and observations. Most of this material is in the MNCN collection and has the original Haas label (Fig. 1). In his paper, Haas mentioned that some specimens were sent by Paz to Lea, who published several new species based on this material (Lea, 1866a, b, 1867, 1869a, b) and Lea did not return part of it. This included four types of species Lea described, and Haas supposed they were in the Lea collection at the United States National Museum, Washington, DC (Haas, 1916).

Table 2. Number of lots in families of freshwater mussels at the MNCN mollusc collection. In brackets the corresponding number of species.

	Africa	America	Asia	Europe	Oceania	Unassigned
Etheriidae	6 (1)					1
Hyriidae		142 (26)			28 (7)	4
Iridinidae	41 (12)	1 (1)				
Margaritiferidae	3 (1)	4 (2)	3 (2)	136 (3)		4
Mycetopodidae		148 (23)				
Unionidae	102 (16)	1,064 (193)	122 (53)	1,336 (15)		125
TOTAL	**152 (30)**	**1,359 (245)**	**125 (55)**	**1,472 (18)**	**28 (7)**	**134**

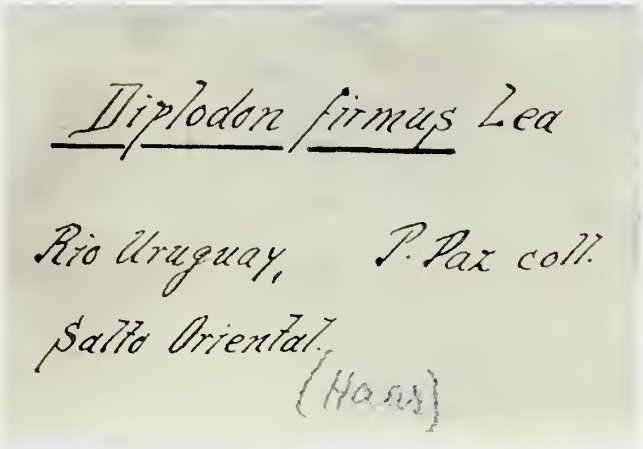

Figure 1. Handwriting of Fritz Haas on the labels of the Comisión specimens.

We located 51 lots of mussels collected by the Comisión (**Table 3.** Freshwater mussels from the Comisión Científica al Pacífico in the MNCN mollusk collection. Posted online at http://nautilus.shellmuseum.org); they include 223 specimens of 22 species belonging to 2 different families. We verified that the specimens sent to Lea by Paz were indeed absent; at least those corresponding to the following seven species described by Lea (1866a, 1869) are not in the MNCN. We have found them at the mollusk collection of the Smithsonian Institution, National Museum of Natural History (Washington, USA): *Unio ampullaceus* Lea, 1866. Type: USNM 85614 (=*Diplodon wymanii* (Lea, 1860)), *Unio locellus* Lea, 1866. Type: USNM 85189 (=*Rhipidodonta variabilis* (Maton, 1811)), *Unio parcus* Lea, 1866. Type: USNM 85198 (=*Rhipidodonta charruana* (Orbigny, 1835)), *Unio acutirostris* Lea, 1866. Type: USNM 85930 (=*Diplodon parallelopipedon* (Lea, 1834)), *Unio apprimus* Lea, 1866. Type: USNM 85167 (=*Diplodon wymanii* (Lea, 1860)), *Unio rugososulcatus* Lea, 1866. Type: USNM 84392 (=*Pachynaias rugososulcata* (Lea, 1866)), and *Unio rufofuscus* Lea, 1865. Type: USNM 84101 (=*Rhipidodonta grata* (Lea, 1860)). Another part of the Paz material is separated between the Smithsonian and the MNCN (**Table 3.** Freshwater mussels from the Comisión Científica al Pacífico in the MNCN mollusk collection, posted online at http://nautilus.shellmuseum.org): *Unio paraguayensis* Lea, 1866. Type: USNM 85068 (=*Diplodon delodontus* (Lamarck, 1819)), *Unio peculiaris* Lea, 1866. Type: USNM 85190 (= *Diplodon wymanii* (Lea, 1860)), *Unio firmus* Lea, 1866. Type: USNM 85113 (= *Diplodon delodontus* (Lamarck, 1819)), *Monocondylaea lentiformis* Lea, 1866. Type: USNM 86335 (=*Monocondylaea corrientesensis* (Orbigny, 1835)), *Monocondylaea pazii* Lea, 1866. Type: USNM 86342 (=*Monocondylaea minuana* (Orbigny, 1835)) and *Anodonta pazii* Lea, 1866. Type: USNM 86703 (=*Anodontites trapezea* (Spix and Wagner, 1827)). Haas (1916), cited Simpson (1914), noting the type of *Anodonta napoensis* Lea, 1868 was also sent by Paz to Lea and it was present in the Lea collections in the Smithsonian Institution, Washington, DC. This was an error by Haas (1916) because Simpson (1914) did not cite Paz as donor but the name of Prof. Orton; therefore, the type specimen of this species at the Smithsonian (USNM 25429) did not come from Paz but from Dr. G. Strebel (Graf and Cummings, 2013). Other material from the Comisión can be found at the Senckenberg Museum of Frankfurt (Haas, 1916; Zilch, 1967; Graf and Cummings, 2013).

The two species described by Hidalgo, *Castalia crosseana* Hidalgo, 1865 and *Castalia pazi* Hidalgo, 1868, have been synonymized under *Castalia ambigua* Lamarck, 1819 and *Rhipidodonta lylaea* (Orbigny, 1835) by Bonnetto (1965) and Simone (2006), respectively. One specimen of each was sent by Hidalgo to the Senckenberg Museum (Frankfurt am Main, Germany) (Haas, 1916). Synonymized by Haas (1969) are the two species described by himself (Haas, 1916), *Diplodon hidalgoi* and *Mycetopoda bolivari*, as *Rhipidodonta charruana* (Orbigny, 1835) and *Mycetopodella falcata* (Higgins, 1868).

It is worth noting the presence of some specimens from the Comisión preserved in fluids (currently in 70% ethanol) at the MNCN collection that were probably overlooked by Haas (1916): 7 specimens of *Anodontites trapesialis* (Lamarck, 1819), 6 specimens of *Anodontites trapezea* (Spix and Wagner, 1827) and 2 specimens of *Diplodon delodontus* (Lamarck, 1819). The remaining 208 specimens are all dry.

We note some differences in the number of specimens recorded by Almagro (1866), Haas (1916) and this paper. For instance, regarding *Anodontites patagonica* (Lamarck, 1819), Haas (1916) cited two lots at the MNCN, one lot of 3 specimens from Río de la Plata and another lot with 2 specimens from Miguelete River, and we have found only one lot, labelled as Río de la Plata, but with 6 specimens, four of them with "Rio de la Plata" written inside the shell. This maybe explained because some material may have been lost or mixed during the last 150 years, or because the data from Almagro (1866) might not be accurate. Almagro's book was written in the last year of the Comisión, so the historical number of species and corresponding number of specimens may be inexact. Another reason could be the loaning or gifting of specimens between different collections and/or the loss of old labels, as occurred among the Paz, Hidalgo, and Azpeitia collections. We have not found the specimens from Montevideo, Negro River, Aguano and Otavalo (Almagro, 1866).

Some years after the end of the Comisión, Paz sent Lea his collection of North American freshwater mollusks for expert identification (ACN0252/002; ACN0259/013). Lea returned the identified specimens (451 gastropods and 287 bivalves) in 6 parcels to La Habana (Cuba), where they were shipped again to Cádiz (Spain) arriving on 12 July 1872. On 22 August 1872 they were moved by train to Madrid where they arrived on 4 September. One year later, in 1873, the Paz mollusk collection,

Table 4. Number of freshwater mussels species included in the IUCN in the MNCN collection. Number total of species included in each category in brackets.

	Near threatened	Vulnerable	Endangered	Critically endangered	Extinct
America	35 (40)	7 (14)	10 (34)	24 (50)	10 (27)
Africa	0 (1)	0 (9)	3 (5)	2 (4)	0 (2)
Asia	0 (2)	0 (6)	3 (9)	1 (8)	
Europe	1 (1)	3 (4)	2 (2)	1 (1)	
Oceania					
TOTAL	**36 (44)**	**10 (33)**	**18 (50)**	**28 (63)**	**10 (29)**

including this material, was sold to the Museo Nacional de Ciencias Naturales (Barreiro, 1992).

ENDANGERED SPECIES

Freshwater bivalves are among the most imperiled animal groups on the planet, declining due to pollution, modified or disturbed habitat and reduced numbers of host fish (Lydeard et al., 2004; Strayer et al., 2004). In cases of imperiled fauna, the role of natural history collections is essential, being the last repositories where scientists can study extinct or endangered species (Nicholson, 1991; Shaffer, Fisher and Davidson, 1998). The MNCN collection has 82 % of all the Near Threatened freshwater bivalve species, 30 % of the Vulnerable species, 36 % of the Endangered species, 44.5 % of the Critically Endangered and 34.5 % of the today's Extinct naiads recognized by the International Union for the Conservation of Nature (IUCN) (Table 4). It also has nearly 60 % of the North American Endangered species (Endangered Species Act) and numerous lots of all the European species protected under the Habitats Directive: *Margaritifera margaritifera, M. auricularia, U. elongatulus, and U. crassus* (Tables 5, 6; **Table 6**. Freshwater bivalve species in the MNCN collection included in the IUCN, the Endangered Species Act and the Habitats Directive. Posted online at http://nautilus.shellmuseum.org).

Margaritiferidae represents one of the most imperiled naiad families. The MNCN mollusk collection contains 169 specimens of *M. auricularia* in 68 lots, 67 from Spain and 1 from France, probably the largest collection of this species in the world (Araujo and Ramos, 2000), 69 lots of *M. margaritifera*, 3 lots of the North African *M. marocana*, 3 of *M. monodonta*, 1 of *M. dahurica*, 2 of *M. laevis* and 1 lot of the Asiatic *M. laosensis*. *Margaritifera laosensis* is quite rare in collections and has only recently been collected alive in the northern region of the Lao People's Democratic Republic (S. Schneider, Personal Communication).

Table 5. Number of freshwater mussels species included in the Endangered Species Act and in the Habitats Direetive in the MNCN collection. Number total of species included in each category in brackets. * We consider *Unio mancus* and *U. ravoisieri* under the same Annex (III and IV) as *U. elongatulus*, and *U. tumidiformis* under the same Annex (II and IV) as *U. crassus* (Araujo et al., 2009).

	Ameriea	Europe
Endangered	43 (73)	-
Threatened	1 (10)	-
Annex II	-	4 (3)*
Annex IV	-	2 (2)
Annex V	-	4 (2)*

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LITERATURE CITED

ACN0252/002. 1872. Archivo del Museo Nacional de Cieneias Naturales, 16 pp.

ACN0259/013. 1872–1873. Arehivo del Museo Nacional de Ciencias Naturales. Expediente relativo a la confusión surgida en el envío de Rafael Arango al Museo de Ciencias de una coleeción de conehas y caraeoles, reclamada por Patricio María Paz como suya, y posterior compra de la misma para dicho establecimiento, 66 pp.

Allmon, W.D. 1994. The value of natural history eollections. Curator 37: 83–89.

Almagro, M. 1866. Breve descripción de los viajes hechos en América por la Comisión Científiea enviada por el Gobierno de S. M. C. Durante los años 1862 a 1866. Mairena de Aljarafe, Sevilla, 174 pp.

Araujo, R., J. Reis, A. Machordom, C. Toledo, M.J. Madeira, I. Gómez, J.C. Velasco, J. Morales, J.M. Barea, P. Ondina, and I. Ayala. 2009. Las náyades de la península Ibérica. Iberus 27: 7–72.

Araujo, R. and M.A. Ramos. 2000. A critical revision of the historical distribution of the endangered *Margaritifera auricularia* (Spengler, 1782) (Mollusca: Margaritiferidae) based on museum specimens. Journal of Conehology 37: 49–59.

Barreiro, A.J. 1992. El Museo Nacional de Ciencias Naturales (1771–1935). El Museo Nacional de Ciencias Naturales, CSIC. Doce Calles, Aranjuez, 509 pp.

Bogan, A.E. 2008. Global diversity of freshwater mussels (Mollusca, Bivalvia) in freshwater. Hydrobiologia 595: 139–147.

Bonetto, A.A. 1965. Las almejas Sudamericanas de la tribu Castaliini. Physis 25(69): 187–196.

Bouchet, P. and J.P. Rocroi. 2010. Nomenclator of Bivalvia Families: with a classification of bivalve families by R. Bieler, J. G. Carter, and E. V. Coan. Malacologia 52: 1–184.

Calvo, M. 1994. Informe sobre el material malacológico recogido durante la "Expedición al Pacífico (1862–1865)". In: M.A. Calatayud. Diario de Don Francisco de Paula Martínez y Sáez. Miembro de la Comisión Científica al Pacífico 1862–1865. Edición crítica, transcripción del original, biografía, notas, itinerario e índices. Consejo Superior de Investigaciones Científicas. Instituto Juan Sebastián Elcano, Madrid, pp. 283–287.

Carter, J.G., C.R. Altaba, L.C. Anderson, R. Araujo, A.S. Biakov, A.E. Bogan, D.C. Campbell, M. Campbell, Chen J.-h., J.C.W. Cope, G. Delvene, H.H. Dijkstra, Fang Z.-j., R.N. Gardner, V.A. Gavrilova, I.A. Goncharova, P.J. Harries, J.H. Hartman, M. Hautmann, W.R. Hoeh, J. Hylleberg, Jiang B.-y., P. Johnston, L. Kirkendale, K. Kleemann, J. Koppka, J. Kříž, D. Machado, N. Malchus, A. Márquez-Aliaga, J.-P. Masse, C.A. McRoberts, P.U. Middelfart, S. Mitchell, L.A. Nevesskaja, S. Özer, J. Pojeta, Jr., I.V. Polubotko, J.M. Pons, S. Popov, T. Sánchez, A.F. Sartori, R.W. Scott, I.I. Sey, J.H. Signorelli, V.V. Silantiev, P.W. Skelton, T. Steuber, J. B. Waterhouse, G. L. Wingard, and T. Yancey. 2011. A Synoptical classification of the Bivalvia (Mollusca). Paleontological Institute, University of Kansas, Paleontological Contributions No. 4, 47 pp.

Graf, D. L. and K.S. Cummings. 2007. Review of the systematics and global diversity of freshwater mussel species (Bivalvia: Unionoida). Journal of Molluscan Studies 73(4): 291–314.

Graf, D.L. and K.S. Cummings. 2013. The Mussel Project. Home Page http://www.mussel-project.net/ [accessed 7 May 2013].

Haas, F. 1915. Spanischer Brief II. Nachrichtsblatt der Deutschen Malakozoologischen Gesellschaft 1: 76–83.

Haas, F. 1916. Náyades del viaje al Pacífico verificado de 1862 a 1865 por una comisión de naturalistas enviada por el Gobierno español. Trabajos del Museo Nacional de Ciencias Naturales, Serie Zoológica 25: 1–63.

Hidalgo, J.G. 1872. Moluscos del viaje al Pacífico verificado de 1862 a 1865 por una comisión de naturalistas enviada por el gobierno español. Parte primera: Univalvos terrestres. Imprenta de Miguel Ginesta, Madrid, 152 pp.

Hidalgo, J.G. 1879. Moluscos del Viaje al Pacífico, verificado de 1862 a 1865 por una comisión de naturalistas enviada por el gobierno español. Parte tercera: Univalvos marinos. Imprenta de Miguel Ginesta, Madrid, 144 pp.

Hidalgo, J.G. 1900. Obras Malacológicas. Parte tercera. Descripción de los moluscos recogidos por la Comisión científica enviada por el Gobierno Español a la América Meridional. Imprenta de Luis Aguado, Madrid, 608 pp.

Lea, I. 1866a. Description of twelve new species of Unionidae from South Ameriea. Proeeedings of the Aeademy of Natural Sciences of Philadelphia, 18: 33–35.

Lea, I. 1866b. New Unionidae, Melanidae, etc., chiefly of the United States. Journal of the Academy of Natural Sciences of Philadelphia 6 (Second Series): 5–65.

Lea, I. 1867. New Unionidae, Melanidae, etc., chiefly of the United States. Journal of the Academy of Natural Sciences of Philadelphia 6 (Second Series): 113–187.

Lea, I. 1869a. New Unionidae, Melanidae, etc., chiefly of the United States. Journal of the Academy of Natural Sciences of Philadelphia 6 (Second Series): 249–302.

Lea, I. 1869b. New Unionidae, Melanidae, etc., chiefly of the United States. Journal of the Academy of Natural Sciences of Philadelphia 6 (Second Series): 303–343.

Lips, K.R. 2011. Museum Collections: mining the past to manage the future. Proceedings of the National Academy of Sciences 108(23): 9323–9324.

Lister, A.M. and Climate Change Research Group. 2011. Natural history collections as sources of long-term datasets. Trends in Ecology and Evolution 26(4): 153–154.

Lydeard C., R.H. Cowie, W.F. Ponder, A.E. Bogan, P. Bouchet, S.A. Clark, K.S. Cummings, T.J. Frest, O. Gargominy, D.G. Herbert, R. Hershler, K.E. Perez, B. Roth, M. Seddon, E.E. Strong, and F.G. Thompson. 2004. The global decline of nonmarine molluscs. BioScience 54: 321–330.

Martínez y Sáez, F. (1869). Moluscos del Viaje al Pacífico, verificado de 1862 a 1865 por una comisión de naturalistas enviada por el gobierno español. Parte segunda: Bivalvos marinos. Imprenta de Miguel Ginesta, Madrid, 78 pp.

Nicholson, T.D. 1991. Preserving the earth's biological diversity: the role of museums. Curator 34: 85–108.

Shaffer, H.B., R.N. Fisher, and C. Davidson. 1998. The role of natural history collections in documenting species declines. Trends in Ecology and Evolution 13(1): 27–30.

Simone, L.R.L. 2006. Land and freshwater molluscs of Brazil: An illustrated inventory of the Brazilian malacofauna, including neighboring regions of South Ameriea, respect to the terrestrial and freshwater ecosystems. EGB, Fapesp, São Paulo, 390 pp.

Simpson, C.T. 1914. A descriptive catalogue of the naiades, or pearly fresh-water mussels. Part III. Unionidae, *Harmandia-Diplodon*. Mutelidae. Bryant Walker, Detroit, 1540 pp.

Solem, A., W.K. Emerson, B. Roth, and F.G. Thompson. 1981. Standards for malacological eollections. Curator 24: 19–28.

Soriano, Ó., M. Villena, and M.S. Alonso. 2001. Catálogo de los Uniónidos (Mollusca, Unionidae) de la Península Ibérica conservados en el Museo Nacional de Ciencias Naturales (CSIC). Graellsia 57(1): 133–152.

Strayer, D.L., J.A. Dowling, W.R. Haag, T.L. King, J.B. Layzer, T.J. Newton, and S. Nichols. 2004. Changing perspectives on pearly mussels, North America's most imperilled animals. Bioscience 54: 429–439.

Suárez, A.V. and N.D. Tsutsui. 2004. Collections for research and society. BioScience 54: 66–74.

Templado, J., L. Baratech, M. Calvo, M. Villena and M.T. Aparicio. 1993. *Los "Ejemplares tipo" de las colecciones malacológicas del Museo Nacional de Ciencias Naturales.* Monografías. Museo Nacional de Ciencias Naturales (CSIC). Vol. 9, 328 pp.

Villena, M., M.T. Aparicio, L. Baratech and J. Templado. 1997. *Los "Ejemplares tipo" de las colecciones malacológicas del Museo Nacional de Ciencias Naturales. Volumen 2.* Monografías. Museo Nacional de Ciencias Naturales (CSIC/AECI). Vol. 13, 170 pp.

Zilch, A. 1967. Die Typen und Typoide des Natur-Museums Senckenberg, 39. Archiv für Molluskenkunde 97(1–6): 45–154.

Book Review

He Jing and Zhuang Zimin. 2013. **The Freshwater Bivalves of China.** ConchBooks. Bahnhofstr. 117 D-55296 Harxheim, Germany.198 pages. 68 €.

This colorful volume is the most complete, well-illustrated book to cover the freshwater bivalve fauna of China to date. The authors point out the early contributions/foundation to our understanding of the Unionidae and *Corbicula* species of China by Pierre Marie Heude (1836–1902) illustrated by outstanding lithographs. His ten-part series was entitled *Conchyliologie fluviatile de la province de Nanking et de la Chine central* (1875–1885). There have been numerous journal articles covering new species and notes on the bivalve fauna of particular Chinese rivers but no compilation of the fauna. Liu Yue Ying (1979) published the *Economic Fauna Sinica – Freshwater Mollusks*, the first modern volume on freshwater mollusks but it was illustrated with only line drawings and was not nearly as detailed or in depth as the current volume. He Jing and Zhuang Zimin's book treats all of the 126 recognized freshwater bivalve taxa in seven families and lists over 1000 synonyms. Five new species of Unionidae are described by the authors. Liu (1979) listed a single species of Sphaeriidae from China, while this work expands the known fauna to include nine species. **The Freshwater Bivalves of China** is the first modern treatment to synthesize available information on this fauna with color pictures and original lithographs where available.

The front endpapers provide a physiographic map of China with major cites marked. The volume begins with an explanatory preface, acknowledgments, museum acronyms and a regional map of China with abbreviations used for major faunal provinces. Species accounts begin with Unionidae. Generic accounts are arranged alphabetically with all species in that genus listed alphabetically. This is followed by the Margaritiferidae, Pharidae, Mytilidae, Dreissenidae, Cyrenidae, and Sphaeriidae. Generic accounts are typically short descriptions of diagnostic shell characters. Species accounts are usually restricted to a single page, but may extend to three pages and contain synonymy, distribution within China, types, a shell description and figures. If original lithographs were provided with the description of the species, these are reproduced, especially those species described by Isaac Lea and Pierre Marie Heude.

It is great to see numerous color photographs of the species where specimens were available and the reproduction of original lithographs of Heude, because his work is not readily available. Pictures illustrating shell shape variation and sculpture are very helpful.

Synonymies for each species appear to be complete and will be very useful in sorting out historic collections and aid in developing future research problems. A synonymy is very necessary when dealing with the eastern Russian named taxa and where those taxa might belong. The distribution table at the end of the species accounts lists species by province and is very useful for distribution of a species and a reference for the local fauna. I especially like the complete and full citation style used in Bibliography. There are no obscure abbreviations to provide puzzles on where to find an article of interest. A list of the valid mussel species is provided and has the three introduced species highlighted and a column on the right with the Chinese names. The most important part of any book is the index. This index includes family and generic names, all species names followed by the generic name under which it appears in the text [valid names are in bold]. Synonymous names are listed as well as those taxa recognized as valid.

As a reviewer, it is always easy to make a list of items one would like to have seen included in the book, but you are not the author of the book nor its editor. However, I would suggest the following changes for the authors to consider for the next edition of this fine volume. It would help to have the photographic view of each valve standardized, outside of the right valve and the inside of the left valve at least. A few of the color pictures are not as sharp as they might be, but all are very helpful. Type section lists recognized specimens that are flagged as various types. The type status of each lot was not discussed and is listed as it appears on label without research. The museum and literature research required to determine the correct status of a type and who is responsible for the correct type determination is beyond the scope of this book. I would caution anyone using this book not take the type status as resolved. Determining the type status for each species will require a lot of work and time. Remarks on each species are limited. In the next edition, a more detailed comparison of similar species and how to tell them apart would be useful. Detailed distributional information for each species would be very helpful, but this information may not be readily available at this time.

This volume should be on the bookshelf of all freshwater bivalve biologists. I would reecommend this volume to anyone interested in freshwater bivalves, first of China and secondly to anyone interested in the zoogeography of freshwater bivalves in Asia. The pictures clearly illustrate the issue of convergence in shell shape and sculpture between Asia and the rest of the world. But, it is also just fun to page through the book looking at the pictures. Hopefully, this volume will spark increased interest, research, and conservation efforts on the freshwater bivalves of China.

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Notice

THE 2014 R. T. ABBOTT VISITING CURATORSHIP

The Bailey-Matthews Shell Museum is pleased to invite applications for the 2014 R.T. Abbott Visiting Curatorship.

The Curatorship, established originally in accordance with the wishes of the late Dr. R. Tucker Abbott, Founding Director of the Shell Museum, is awarded annually to enable malacologists to visit the museum for a period of one week. Abbott Fellows are expected, by performing collection-based research, to assist with the curation of portions of the Museum's collection and to provide one talk for the general public. The Museum collection consists of marine, freshwater, and terrestrial specimens. A large percentage of our holdings have been catalogued through a computerized database management system; part of the catalogue is already available for searches online at: www.shellmuseum.org/collection.cfm. The R.T. Abbott Visiting Curatorship is accompanied by a stipend of $1,500.

Interested malacologists are invited to send a copy of their curriculum vitae, a letter detailing their areas of taxonomic expertise and research objectives, and to provide a tentative subject for their talk. Send materials to:

Dr. José H. Leal, Curator & Director of Education
The Bailey-Matthews Shell Museum
P.O. Box 1580
Sanibel, FL 33957
jleal@shellmuseum.org

Applications for the 2014 Visiting Curatorship should be sent electronically to the above e-mail address no later than May 31, 2014, or postmarked by that date if sent by regular mail. The award will be announced by late June 2014. Questions about the Visiting Curatorship should be sent to the e-mail address above, or by phone at:

(239) 395-2233; fax (239) 395-6706

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THE NAUTILUS publishes articles on all aspects of the biology, paleontology, and systematics of mollusks. Manuscripts describing original, unpublished research and review articles will be considered. Brief articles, not exceeding 1000 words, will be published as notes and do not require an abstract. Notices of interest to the malacological community will appear in a notices section.

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Text must conform to the dimensions of 8½ × 11-inch paper, double-spaced, and single-column throughout (including literature cited, tables, and figure captions). Authors should follow the general recommendations of *Scientific Style and Format—The CSE Manual for Authors, Editors, and Publishers*, available from the Council of Science Editors at www.councilscienceeditors.org. The first mention of a scientific name in the text should be accompanied by the taxonomic authority, including year. Latinized names and other words to be printed in italics must be underlined; leave other formatting indications to the editor. Metric, not English, units are to be used. Geochronologic modifiers should be capitalized only when units are formally recognized: for instance, use Late Cretaceous but early Miocene. Likewise, only modifiers of formally recognized chronostratigraphic units are capitalized: use Lower Jurassic but upper Oligocene.

The sequence of sections should be title page, abstract, introduction, materials and methods, results, discussion, acknowledgments, literature cited, tables, figure captions, figures. The title page should include the title, author's name(s) and address(es). If corresponding author is not the senior author, please indicate. The abstract should summarize in 250 words or less the scope, main results, and conclusions of the article. Abstracts should be followed by a list of additional key words. All references cited in the text must appear in the Literature Cited section and vice-versa. Please follow a recent issue of THE NAUTILUS for bibliographic style, noting that journal titles must be unabbreviated. Information on plates and figures should be cited only if not included within the pagination of cited work. Tables must be numbered and each placed on a separate page. If in doubt, please follow a recent issue of the journal for sequence of sections and other style requirements.

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